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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C.3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

SOIL EROSION.

OPPORTUNITY is taken to reproduce the following passages from an article dealing with the question of soil erosion in the British Empire, recently contributed to *The Times Weekly Edition** by Elspeth Huxley. The author's remarks, largely confined to Africa, are pertinent to a serious problem which fortunately is being given the wide publicity that it deserves. "The greater part of Africa, it is stated, is, in fact, very subject to erosion. The process, through centuries, has robbed the continent of vast acreages of once productive soil . . . In Africa, water supplies are perhaps the greatest limiting factor in development. The continent is scarred with dry river beds that must once have flowed all the year round. One day the much-abused tsetse fly may be honoured, like the cotton boll weevil, by commemoration in a statue, erected as a tribute to its great work as 'guardian of the waters'. For the tsetse fly, by keeping cattle away, has protected land alike from overgrazing and from cultivation, and so preserved vegetative cover and ensured the even flow of streams. In certain areas, notably Tanganyika, Governments are conducting large-scale campaigns against the tsetse. The success of such measures cannot fairly be judged until their effect on water supplies has been observed 20 or 30 years hence."

"For the past century in Africa vegetative cover has been slowly but steadily stripped from the land, and the process continues to-day at an accelerated rate. Only about 10 per cent. of Africa is under trees; the right amount for the safety of soil and of water supplies would be about 30 per cent. The growth of population that is taking place means that more cultivated land is needed to support a larger number of people. And the drives which nearly all Colonial Governments have undertaken in recent years to increase production of native-grown crops for export have been extremely successful. Like most excellent aims, this increase in native-grown exports has its dangers. The gravest is the threat to the safety of the top-soil."

"Some other European efforts to enlighten the native are turning out to be suspiciously like agricultural boomerangs. The traditional African method of planting, for instance, is to sow all the crops haphazard in one field—beans, field peas, sweet potatoes, maize, yams, all mixed up together to form a fairly thick anti-erosive mat

* Thursday, June 17th, 1937.

over the soil surface. From Europeans the native peasant has learnt to plant crops singly and to plant in rows, thus leaving the soil far more exposed to erosive influences."

"Another improvement that needs to be watched is the introduction of the plough. Ploughs enable land to be laid bare in large blocks, which are far more susceptible to erosion than the small 'gardens', dug with a broad-bladed sword, of native tradition. To hesitate over introducing improvements like the plough, or over encouraging increased native production on account of the dangers involved, would, of course, be a defeatist policy, even if it were a possible one. What is needed is a more carefully thought-out plan of progress."

"The advent of European rule in Africa has tipped the scales of Nature's balance which normally maintain an equilibrium between live-stock and the land. Rinderpest has been controlled by double inoculation, East Coast fever localized by means of dipping, and other diseases overcome. And the cessation of tribal raiding has put a stop to once frequent migrations, so anchoring stock populations to limited areas of grazing in a manner unknown before in history. The result has been an immense increase in the number of cattle and goats, unaccompanied by any corresponding increase in the carrying capacity of the pastures."

"A case in point is the Wakamba reserve in Kenya. The cattle population is estimated at 250,000 and the present carrying capacity of the land on which they exist has been put at 20,000. The result is that the pastures have been trampled and over-grazed to such an extent that grass has been killed, bare land exposed to the elements, and erosion in its acutest and most rapid form has set in . . ."

"The damage done by cattle and sheep, however, is mild compared with what can be done by goats. It would not be exaggerating to describe these prolific animals as the curse of Africa. They are said to have destroyed the fertility of ancient Greece, and they are well on their way towards repeating their grisly triumph over the vegetation of Africa. They eat not only grass but bush, roots and bark. No young tree or shrub can establish itself where goats are allowed to browse. Economically useless—the common African goat has virtually no commercial value—they do not even supply their owners with milk or, except on rare occasions, with meat. In the old days a fair number were killed for religious or magical reasons as sacrifices, but the spread of education and Christianity has virtually put a stop to this partial but once significant form of goat control."

"The limitation of stock is admittedly a complex and difficult question, for it reaches down to the foundations of African belief and custom. But stock must be limited to the number the land can support without injury, and maintained at that evel".

"A survey of erosion in Kenya is now being made by an agricultural officer seconded for the purpose, and a scheme for the reconditioning of the Wakamba reserve, combined with regulation of stock, has been outlined. It is estimated to cost £120,000, spread over four years. That Kenya's revenues could provide this amount is unlikely; and if the scheme were adopted the money would have to be sought from a loan or from Imperial sources, as in Basutoland.* The merit of this or some similar scheme is one of the questions on which Sir Frank Stockdale, the Agricultural Adviser to the Colonial Office, is expected to report after his East African tour. It is hoped by many that his recommendations will mark the end of discussion and the beginning of action".

* In Basutoland erosion damage has reached so acute a stage that the Colonial Development Fund recently made a grant of £162,000 for the construction of anti-erosion works.

OBITUARY.

Sir Cecil Hanbury.

It is with great regret that we have to record the death on 10th June, from a heart attack of Sir Cecil Hanbury who had been a Governor of the Imperial College of Tropical Agriculture since 1928.

Educated at Fettes, and Trinity College, Cambridge, where he took his degree in 1892, Sir Cecil travelled widely in the Far East and the Colonies and became a partner in Ward, Hanbury & Co., China merchants of London and Shanghai. During the war he served in the Foreign Office and the Admiralty. He had been Unionist member for North Dorset since 1924 and was knighted in 1935.

Sir Cecil's family has been connected with Italy for over 70 years and he spent a considerable time every year at his villa at La Mortola, Ventimiglia, where he owned a magnificent garden famous for its beauty and a remarkable collection of plants of great botanical interest. In order to maintain the scientific character of the La Mortola gardens an exchange of students between La Mortola and Kew was started several years ago, much to the mutual advantage of both institutions. So successful was this arrangement that it led subsequently to the present extensive system of exchanges of Student Gardeners between Kew and Botanical Gardens in many parts of the world. Sir Cecil was the brother-in-law of the late Sir James Currie; and with his wide interests and sympathies proved a valued Governor of the College.

THE BIOLOGY OF THE FUNGUS-GROWING ANTS.

PART II. (1) Nesting Habits of the Bachac (*Atta Cephalotes* L.).

By Neal A. Weber.

I. Introduction.

To anyone familiar with agriculture in the New World Tropics the importance of the large leaf-cutting ants (2) (*Atta* spp.) is obvious. Their depredations on cassava, citrus, mango and cultivated plants in general have been frequently chronicled from the times of the earliest white travellers in these regions.

Since the usual ways of destroying the bachac ant (*Atta cephalotes*) in Trinidad are by gassing or by digging up the nest, a knowledge of the nest structure is important. While the large and mature nests are the ones usually attacked, it is clear that the earlier a nest is recognized as such, the easier may it be destroyed. The early stages of every nest are therefore briefly described in these notes.

II. Distribution.

The exact range of this species is not known but it has been reported from Mexico to Bolivia and the basin of the Amazon. I found it to be the sole *Atta* in the Orinoco Delta, Venezuela, but in British Guiana it occurs with *Atta sexdens* in the Essequebo basin, though occupying a different ecological niche. I found only *Atta sexdens* in the Courantyne basin of British Guiana and Surinam.

The bachac ant is distributed generally over Trinidad. Representative localities in which I have collected it include :

Northern Range : Santa Cruz, Maracas and Caura Valleys, Spring Hill Estate, slopes of Morne Bleu, Tacarigua and Aripo Rivers.

Manzanilla and Mayaro Bays, Nariva Swamp, Trinity Hills and Basin Hill Reserves, Turure River.

It is naturally absent from the Caroni Swamp and similar areas of mangrove swamps. I have not seen it on the Piarco Savannah and it may be absent from other open savannah areas which have too sparse vegetation or are otherwise unsuitable. The persistent and intensive cultivation of many lowland areas and destruction of the nests over a period of several centuries have kept down the numbers of these ants in such places. The closely related but less conspicuous ant, *Acromyrmex octospinosus* Reich, often called the "small bachac" is more widespread in Trinidad and I have taken it also on the Bocas del Dragon islands of Gasparee, Monos, and Patos without finding the bachac.

While usually the nests are inland from the seashore, one at Mayaro Bay was under coconuts at the very edge of the beach, just above high tide level. On the other hand, I did not find these ants on the summit of El Tucuche (3,072 feet) or above 1,800 feet elsewhere in the Northern Range though doubtless they may occur several hundred feet higher in suitable situations. The limiting factors here are probably continuously saturated soil and dripping wet vegetation rather than altitude in itself. The altitudinal range of this species in Trinidad from available records is thus sea-level to 1,800 feet.

III. Nesting Sites.

The bachac is distinctly a forest ant. It is abundant in the rain forests of the Orinoco Delta in Venezuela and in the similar forests of British Guiana but does not extend into the llanos or savannahs of either country. The habitat in Trinidad is similar and no forests are too dense for it.

The nesting sites are consequently often in heavy shade and very little exposed to the sun at any time of the day. Nests are sometimes found in the forest on steep slopes but the amount of sunlight received would be small in nearly every case. The nest at Mayaro Bay previously mentioned received full sunlight only in the earliest hours of the morning; during the rest of the day it was shaded by coconuts. Back from this beach another nest (Fig. 6) was situated on the grassy south side of a slope and received full sunlight for at least the first half of the day. The west side of the nest extended under trees and may have been the original site.

Young nests are occasionally found on very steep and exposed slopes, in roadways and in other unfavourable positions. These are probably the site of the chance alighting of the female. The resulting colonies either may not survive or may gradually extend the growing nest into a neighbouring more favorable environment.

According to my observations the bachac is predominately an ant of heavy clay soil while the related *Atta sexdens* of the mainland is usually found nesting in sand.

IV. The Nest.

The nest in the fungus-growing ants affords shelter for the colony and a suitable stable environment for the delicate fungus upon which

(1) "Part I. New Forms" is to be published in the *Revista de Entomologia* (Rio de Janeiro).

(2) *Atta cephalotes* is commonly known in Trinidad under the name of "bachac." The ants of this genus are so well-known in many other countries as to have been given common names. Among these are : Cuba —"bibijagua" (*A. insularis*) ; Mexico—"hormiga arriera" (*A. mexicana*) ; Guatemala—"zampopos" (Dr. W. M. Wheeler) (*A. cephalotes*) ; Venezuela— "bachako" (*A. cephalotes* and *A. sexdens*) ; British Guiana—"cushi," "cuschi," or "acushi" (*A. cephalotes* and *A. sexdens*) ; Surinam—"parasolmieren" (*A. sexdens*) ; Brazil—"sauba" (*A. sexdens*) ; Peru—"coqui" (Dr. G. Walcott) (*Atta* sp.).

the ants are completely dependent. The brood of the bachac is always kept within the fungus garden, in cells throughout the honeycombed mass of fungus and substrata. The varied adaptations to local conditions found in the nests of the bachac consequently may be interpreted as subserving one or both of these functions.

The location of the typical nest in soil within the heavily shaded tropical forest automatically insures an even temperature the year around and relatively constant humidity during each of the dry and wet seasons.

During excessive rains, however, the soil may become saturated with moisture, and soil under the fungus garden is removed, as is shown particularly in Fig. 2. The garden in any event does not touch the walls or roof of the chamber but in water-logged soil it is also well suspended on stones or roots at the base. Many gardens gain additional stability by support from roots entering the walls or ceiling (Fig. 3).

During rains the nest opening or openings may be closed with soil or used-up substrata as is shown in the photograph of the surface of the young nest in British Guiana (Fig. 4) and as was the condition in the previously mentioned Trinidad nest (Fig. 2) when it was discovered. This habit, however, serves also to retain humidity during droughts and to keep out intruders and light during the day. Young colonies particularly and older colonies frequently, are nocturnal or crepuscular in that they are active above the surface in cutting and gathering leaves only during the night or in the twilight.

A.—Early Stages.

Colonies of the bachac are usually, if not always, started independently by a single female. Following the marriage or dissemination flight the fecundated female descends to the ground at a point probably determined by the strength of her wings, air currents, rain, natural barriers, or other factors largely of chance. She then loses her wings at a predetermined suture and digs into the soil. The odds, of course, are greatly against her and many ants fall prey to other animals or fail to land on suitable soil.

Field observations on the very beginning of the nest are lacking but experiments in the laboratory indicate the process is the same as for many other ants which have been observed in nature. Virgin females taken from their nests and kept with parts of their colonies retain their wings indefinitely. When such a single female is taken from the nest, and placed in a separate container with soil, after first cutting off her wings with scissors, she immediately starts making a cell. If she is provided with only a shallow layer of moist and coarse sand she uses this to wall up the sides and ceiling of the container, thus cutting out the light as well as providing a chamber where the humidity would be practically uniform throughout. If more suitable and deeper soil is given, she digs a tunnel. In one instance two such artificially dealated virgin females were placed in the same container. No animosity was shown to one another. By the next morning they were found to have excavated a narrow tunnel several centimeters deep and were busily engaged in deepening it. There being room in the tunnel for but one at a time they were taking turns, one waiting for the other to come out with a load of sand and then immediately darting in before the other could deposit the load at the periphery of the chamber and return. They actually jostled one another in their eagerness to excavate. For eight days they occupied the tunnel together but on the morning of the ninth, one was found, dead but undamaged, firmly packed in sand at the end of the tunnel.

Through the investigations of von Ihering (1898), J. Huber (1905) and others on *Atta* in Brazil and verified recently by myself in Trinidad on *Acromyrmex octospinosus* Reich the next stage is known.

Before the marriage or dissemination flight the winged females have acquired in their infrabuccal pocket a pellet from the parental nest containing hyphae from the fungus garden. After completing the tunnel with its enlarged end in the form of a small cell the ant ejects this pellet and manures it with her own liquid feces. The hyphae grow and a miniature fungus garden is soon developed on which the ant lays her eggs. This behavior pattern is so strong that several times I found virgin female ants, taken from the parental nest before their normal time for emergence and without this hyphal pellet, attempting to develop a fungus garden by gathering a cluster of sand grains and manuring them. The eggs develop through larval and naked pupal stages into minima workers. These workers break through the soil to the outside, the tunnel being perhaps closed as much from filling up with débris and soil brought in by rains or winds as from the activities of the female ant, and bring in fresh substrata to the fungus garden. Von Ihering estimated the first brood appeared within two or three months.

Upon the successful emergence of the first brood a critical stage has been passed and these workers relieve the weakened female of the necessity of maintaining a garden upon her own feces which must indeed be limited by this time. (She eats the majority of her eggs.) The workers bring in small particles of vegetal débris, including sections of dead leaves. Since they are too small to cut green leaves this type of substratum is left for successive broods and is the economically important feature of the mature colony.

Some of these very young colonies develop a chimney or turret entrance to the nest from the soil carried up in their excavating, others deposit the soil in the form of a low disc or crater. Both types of nests are shown in the accompanying photographs (Figs. 1-4). Of the two photographs of chimney entrances, the smaller (Fig. 1) was 11 cm. high and perpendicular, the larger (Fig. 2) 12 cm. high and leaning at an angle of about 25°; both were on steep slopes. This type of entrance

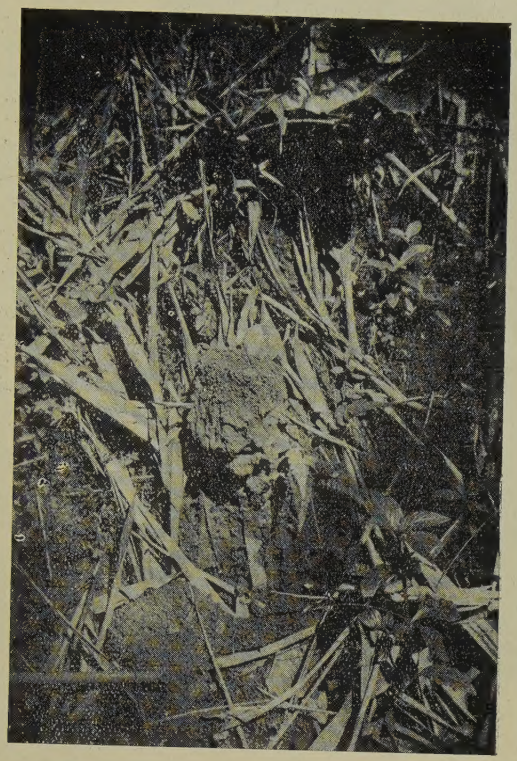

FIG. 1.

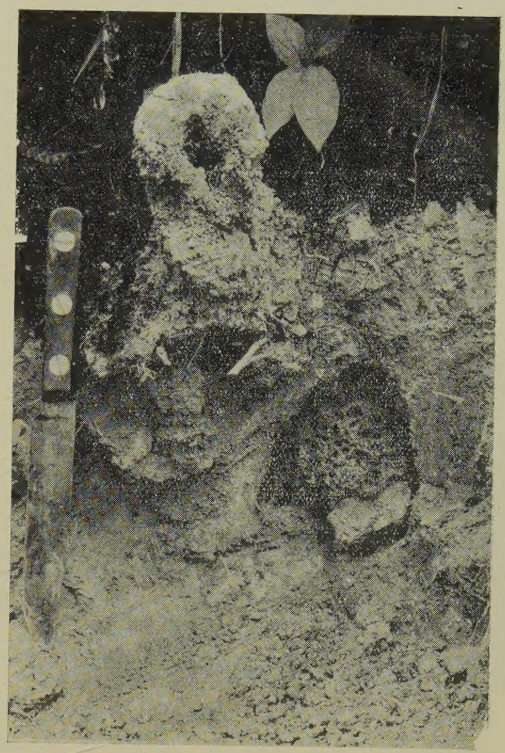

FIG 2.

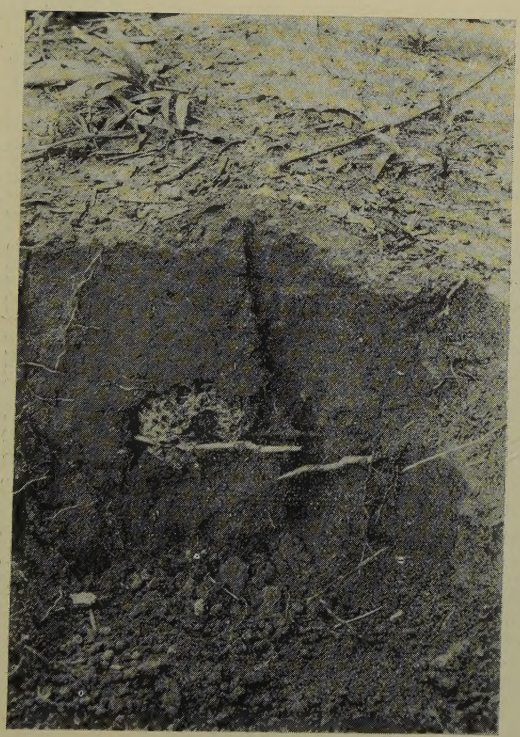

FIG. 3.

FIG. 4.

FIG. 1.—Chimney entrance to young nest in side of steep bank. English penny on crown. Ants have dropped sand grains from their excavating over the rim of the chimney to slope beneath. December 20, 1934. Caura Valley, Trinidad. FIG. 2.—Large chimney entrance to young nest on steep slope. Knife 10 inches (254 mm.) long. Note well-drained, initial chamber containing fungus garden. April 9, 1935. Aripo Valley, Trinidad. FIG. 3.—Vertical section of initial chamber started by the queen and enlarged by the first broods. Queen clinging to middle of nest above horizontal root. February 6, 1935. Orinoco Delta, Venezuela. FIG. 4.—Inconspicuous disc-shaped entrance to young nest in sand. Entrance (in middle) closed during day by used-up substrata of leaf sections and sand. Diameter about 30 cm. August 18, 1935. Forest Settlement, Mazaruni River, British Guiana.

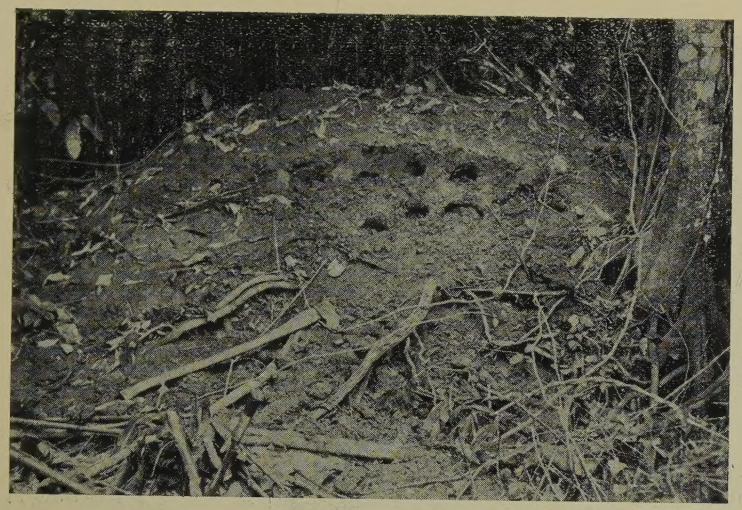

FIG. 5.

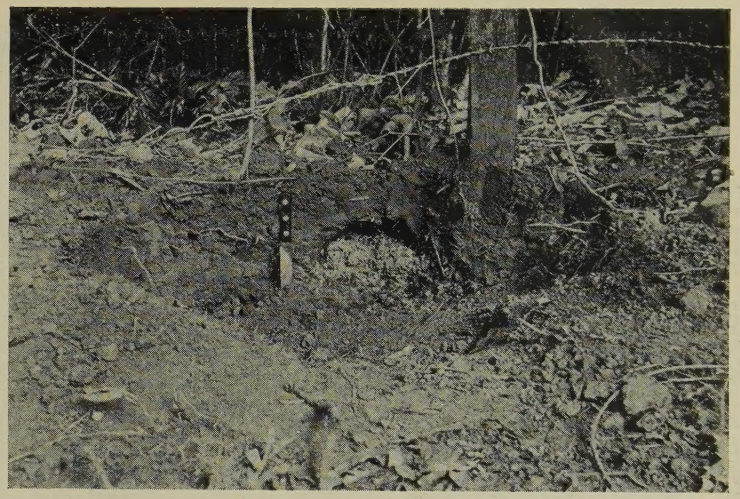

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 5.—Large mound nest in form of truncate cone of fused craters with seven fungus gardens exposed on one side. Gardens exposed were distinctly above general soil level as an adaptation to closeness of water table during rainy season. Diameter 3.7 meters, height 1.4 meters. Scale indicated by Venezuelan axe. February 12, 1935. Orinoco Delta, Venezuela. FIG. 6.—Detail of large nest, partly on grassy slope, partly in forest. One fungus garden exposed. Knife 10 inches (254 mm.) long. June 2, 1936. St. Bernard Estate, Mayaro Bay, Trinidad. FIG. 7.—Part of low nest 11.5. × 13.8 meters with huge mushroom 34.3 cm. high growing from abandoned fungus garden on periphery in middle background (to left of crooked tree). Clearing made by the ants. June 19, 1936. Oko River, Cuyuni tributary, British Guiana. FIG. 8.—Part of a mature nest showing older and levelled part in foreground with newly formed craters in background up to 40 cm. high. March 10, 1935. Nariva Swamp, Trinidad.

on a slope would be more easily kept open against filling up with débris and soil washed down from above than a crater entrance. Both of these chimneys were in heavy clay. The disc or crater entrance on the other hand was found with nests built in more sandy soil and on more level ground. Chimney entrances could hardly be maintained during the rainy season where the nest was on friable sand.

It is therefore probable in this species that the shape of the nest entrance is at least partly an adaptation to soil and slope. Young colonies of *Atta sexdens*, which I have found only in sandy soil, develop disc or low crater nest entrances whether on level ground or on slopes.

The depth of the first and only chamber of the very young nest is determined primarily by the depth reached by the female at the time she started her garden and secondarily by the enlarging activities of the first broods to accommodate the growing colony. Of eight colonies in this early stage the average distance of the ceiling of the chamber from the surface was 105 mm. The maximum was 128 mm., the minimum depth 65 mm. There was no relation between the depth down and the diameter of the chamber. The maximum diameter of the chamber varied from 45 mm. to 150 mm. and this variation probably reflected merely differences in age of the colonies. The maximum diameter was sometimes in the vertical plane, sometimes in the horizontal plane.

The flourishing young colony eventually outgrows the initial chamber and builds a second deeper in the soil. To this chamber the fungus garden is moved and the first chamber becomes a temporary refuse chamber for used-up substrata and dead ants. The second chamber is usually formed much deeper in the soil. In one nest the second chamber was only five centimeters below the first but the shallowness here could be readily explained by the situation, which was in poorly drained soil in the Nariva Swamp. In the majority of nests the vigorous young colony builds the second chamber as deeply as the drainage and other edaphic conditions permit.

B.—Mature Stage.

Growth of the nest from the single-chamber stage is rapid and other chambers are comparatively rapidly added in all directions, some being as shallowly situated as the original chamber. Chambers in the mature nest are of about the diameter of a man's head and the fungus garden only slightly smaller (Fig. 6).

The form of the mature bachac nest is highly variable and represents adaptations to edaphic conditions. The nest furthermore never reaches a static phase but is being continually altered by the ants as the colony grows and as any important part of the environment changes. Photographs of four such mature nests are shown (Figs. 5-8) and illustrate several variations in form.

Only a small part of the Mayaro Bay nest with one fungus garden is shown (Fig. 6) but the externally inconspicuous feature of this part of the nest is indicated. Part of the nest was situated on a grassy slope and part extended under bordering trees and bushes. Very little excavation was being carried on and new soil craters were few in number and small in size. The nest of numerous chambers doubtless covered an area of fully 200 square meters and some of the gardens were within seven or eight centimeters of the surface.

The large mound nest in the Orinoco Delta, Venezuela (Fig. 5), illustrates a vertical rather than a horizontal method of growth in external form caused by the fusion and superposition of new upon old craters. The nest was situated on the left bank of the Rio Grande opposite Isla Sacoroco on a gentle slope about 4.6 meters above high tide level during the dry season and evidently would be close to high tide level in the rainy season. This fluctuation in water table was probably the cause of the ants building up the nest so that some fungus gardens were distinctly above the general soil level. The uppermost fungus gardens were only 5-10 cm. beneath the surface. The diameter of the nest was 3.7 meters and the height 1.4 meters.

V. Influence of the Nest on the Plant Environment.

In its early stages the nest has a negligible effect on the immediate environment. In a large and flourishing nest, however, there is a distinct alteration in that part of the forest above and close to the nest. In the photograph of the Nariva Swamp mature nest (Fig. 8) the high craters mark the youngest part. To the left and in the foreground a bare area appears which was undoubtedly honeycombed beneath by fungus gardens as was indicated by the tunnels in various places throughout. Many such nests in bare areas in otherwise dense forest have been found and I long suspected that the ants were responsible but the clearest proof is presented by a study of the nest from British Guiana upon which was growing the huge mushroom (Fig. 7).

This nest occupied an area 11.5 × 13.8 meters or roughly 160 square meters which was largely cleared of vegetation. Only the larger trees and a few saplings and vines remained alive on the nest. One live sapling 3.7 meters high, in the centre of the nest, was completely defoliated by the ants. Another 3 meters high was half-defoliated. A third 1.7 meters high had but two leaves on it, ¼ of one and ½ of the other leaf being cut away. There were growing on the nest about six different species of saplings and several species of vines all of which had been partially defoliated. These ants cut such characteristically shaped segments from leaves as to leave no doubt but that they were the animals responsible, particularly when their refuse heaps were littered with such dried segments.

It is evident that defoliation of vegetation growing on or close to the nest, even if intermittent and partial, may result in killing off the plants over a period of years. Furthermore, once a colony has attained a large size the ants could

easily cut down seedlings starting up on the nest so that there would be no replacement. An additional factor to consider would be the increased aeration of the soil through being honeycombed with large chambers, which might be unsuitable for many plants.

The result, therefore, is that a mature nest occupies an area in the forest distinctly denuded of low herbaceous plants and the smaller trees.

VI. Summary.

The often huge and conspicuous nest of the large bachac ant (*Atta cephalotes* L.) originates from a small cell hidden in the soil and excavated by a single female after she has descended to the ground from her single marriage flight. In this cell she grows a fungus garden upon which she lays eggs that develop into minima workers. The early broods break through the soil to the outside and bring in fresh substrata for the garden. Growth of the nest is rapid from this early stage to the mature stage in which many fungus gardens of about the size of a man's head honeycomb a large area. It is in the mature stage that the colony becomes economically important because of the habit of the workers of cutting leaves of cultivated crops to furnish substrata for the fungus upon which the ants are dependent for food. Obviously the mature stage can be eliminated by destroying the young nests, and descriptions and photographs of these are given.

THE SUGAR AGREEMENT.

A five year agreement recently concluded the International Sugar Conference at which 22 sugar producing and consuming nations, covering about 90 per cent. of the world output, were present. Under the agreement the exports of sugar from the principal producing countries are to be controlled by a system of quotas, and the Colonial Empire's share in these exports has been limited to a basic figure of 965,254 tons per quota year. Through this division of markets by a system of quotas it is hoped to bring about an adjustment between supply and demand and to give greater stability to the market as a whole. Now that the world demand for sugar is rising the scheme will probably succeed. On the other hand, it must be admitted that although the control of supplies may compensate exporting countries for the expansion of trade which would have resulted from a reversal of restrictionist policies pursued by many importing countries, it will do so at the expense of consumers. Also, according to one of our contemporaries* "it is open to grave doubt whether the expedient of placing the world's probable future consumption at an unexpectedly high level in order to secure any kind of agreement among exporters will be proved beneficial. If prices are kept high the potential increase of consumption will be discouraged".

* *The Economist*, May 8th, 1937, p. 332.

OBITUARY.

Mr. Gordon Cowan.

We much regret to announce the death at Tamale, on 8th May of Mr. Gordon Cowan in his 34th year. Mr. Cowan who was educated at Edinburgh Academy and Glasgow University joined the Imperial College of Tropical Agriculture as a Colonial Agricultural Scholar in 1927. After taking the Associateship course he was posted in 1928 to the Gold Coast Department of Agriculture where at the time of his death he was a member of the Experimental Station Staff. Except for one tour in the Western Division his whole service was spent in the Northern Territories of the Gold Coast. The following tribute is paid to him in the May issue of the Department's monthly news letter: "No one who knew him would fail to be impressed by the transparent sincerity of his character which together with his kindly and tolerant nature had gained him the affection of the whole community. He set a fine example both in his work and social life, and his loss at so early an age will be keenly felt by a wide circle of friends and acquaintances".

"Gordon" as he was always familiarly known to us was most popular as a student and during his short stay in Trinidad his fine personality and generous disposition won him many friends among both staff and students.

SIR ELIOT ARTHUR DE PASS, K.B.E.

As we go to press we learn with deep regret of the death on Sunday, July 11th, in London, of Sir Eliot Arthur de Pass, K.B.E., who was President of the West India Committee and had been a Governor of the Imperial College of Tropical Agriculture since 1925.

PRUNING THE TEA PLANT.

J. R. Tubbs (*J. Pom. and Hort. Sci.*, 14, 4, 317 1937) has estimated that the young shoots of the tea plant (*Camellia Thea*), of which the majority of leaves are normally harvested almost as fast as they grow, have produced at the time of harvesting only half the amount of carbohydrate used up in their development. The consequent continual depletion of the reserves of the bush frequently causes die-back of branches, followed by fungal attack and the death of the whole bush. An investigation of plantations at 200 ft, 1,500 ft. and 4,600 ft. above sea-level showed that die-back was more common at the lower elevations, and smaller amounts of reserve carbohydrate were found in the roots. Several methods of pruning were tried, and it was found that by allowing a number of branches to retain their foliage, a method designed 'lung-pruning', the drain on carbohydrate was checked and the incidence of die-back reduced.—(*Nature*, Vol. 139, No. 3525, p. 889, 1937.)

TROPICAL FRUITS AND VEGETABLES. AN ACCOUNT OF THEIR STORAGE AND TRANSPORT.

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(Continued from *Tropical Agriculture*, XIV, 7, 1937.)

Egg Plant.

The egg-plant, melongene, or aubergine (*Solanum melongena*) a shrub native to Arabia, is now widely cultivated in tropical and sub-tropical regions. In large varieties, the fruit, which is useful as a cooking vegetable, may weigh two to three pounds.

According to Moxsy (3), egg-plant fruits for export should be reaped when of a dark purple colour, before they turn brown or yellow, *i.e.*, they should be harvested when still somewhat immature. Export fruits are graded for size, wrapped in glazed paper and packed, tightly but without squeezing, with wood wool, in standard Florida pepper crates (slatted crates with panel ends, measuring 24 × 16 × 11½ inch) which contain 50 to 55 lb. of fruit. Smith (6) recommends slatted crates measuring 18 × 12 × 9 inch.

In analytical studies Culpepper and Moon (2) found that in fruits picked at the usual stage for table use, the sugar content had reached its highest value; the starch content, which varies little with maturity, was small in amount; titratable acidity and astringency reached their lowest values at this maturity.

Storage Temperature.

Egg-plants, both of the long-narrow, and short-round types grown in Trinidad and stored with air-blast refrigeration at 45° and 50°F., with relative humidities of 80 to 85 per cent. and 80 per cent. respectively, lost weight rapidly, approximately 20 per cent. in 32 days, and became slightly shrivelled. At 45°F., evidence of chilling in the form of an internal brown discoloration was observed in some of the fruits in the course of 32 days' storage, but the flavour, on cooking those fruits which had not become discoloured, was not noticeably impaired (7).

According to Smith (6), early season, Jamaica grown egg-plants carried satisfactorily to England at a temperature of 42° to 45°F. but later supplies showed some wastage.

Platenius *et al* (4) record having held American grown egg-plant fruits at 32°F. for one month; the fruits were very subject to storage diseases and to physiological breakdown, the latter being characterised by a gradual browning of the flesh; at temperatures above 40°F. a marked tendency to shrivelling was observed; they conclude that storage for two to four weeks at 32° to 40°F. may be expected. Rose *et al.* (5) recommend a temperature of 50° to 60°F. and R.H. of 80 to 85 per cent. for the storage of egg-plant fruits up to ten days. Brooks, Bratley and McColloch (1) record that egg-plant fruits were injured by various carbon dioxide treatments to which they were subjected, a pitting, browning and scalding of the superficial tissues being induced.

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Endive and Escarole.

For these salad vegetables (*Cichorium endivia* and *C.* sp.) the best holding temperature is considered to be 32°F., with a high relative humidity, 90 to 95 per cent. If stored in good condition they should retain their quality for two to three weeks. The holding period can be extended by applying crushed ice to the crates (2, 3). Brooks *et al.* (1) observed that escarole was unfavourably affected by high, 50 per cent., or medium, 25 per cent., concentrations of carbon dioxide, the central leaves becoming brown as a result of the treatments.

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Figs.

Fresh figs are very delicate and require careful handling; only choice fruits should be picked for this industry. The fruits must be harvested when of a light green colour and soft to the touch *i.e.*, they must be ripe on picking, otherwise they do not ripen properly or develop their full flavour (9). According to Gould (3) and Stansel

and Wyche (6) fruits should be picked full-grown but just prior to softening. The fruits are severed by means of a sharp knife, about one inch of stalk being left attached. The soft skin is very subject to bruising or breaking; this is followed by high mould wastage. In California, the fruits are packed in eight to ten pound boxes lined with paper, corrugated cardboard being used to separate the several layers. Immediate precooling to prevent the development of sourness (10) and transport in refrigerator cars are necessary to ensure the arrival of sound consignments on distant markets (7). According to Woodroof (10) it has been impossible to sell Georgia grown figs on a commercial scale because of their inability to stand shipment.

Gould (3) has pointed out that in more or less arid countries, figs can be left on the tree without deterioration until they are ripe enough to drop of their own accord. On the other hand, in warm humid regions, ripe figs are very perishable, some varieties being more so than others. Such fruits tend to ferment and deteriorate very soon after picking. Prompt utilisation or handling is therefore necessary, especially in damp, muggy weather. Wet weather and warm humid conditions also promote wastage by fungal pathogens. Fruits ripening under conditions of high humidity and low temperature are also subject to splitting, because of their inability to withstand increased turgor. This type of wastage, which opens the way for souring organisms, is most severe in showery weather (3).

In storage trials at 32°F. and 45°F. with table-ripe fruits of several of the common varieties cultivated in Hawaii, Wilcox and Hunn (8) observed that although some superficial mould developed on the rind, the colour and flavour and physical condition of the pulp remained unchanged for a period of one month. This was followed by deterioration on the 44th day, the figs held at 45°F. breaking down sooner than those at 32°F. The conclusion was reached that figs, even in a ripe condition, may safely be held in cold storage at 32°F. for a period of about one month, the flavour being as good as that of freshly picked fruit. Good results have also been obtained with figs stored at 32° to 34°F. (4). Williams (9) records successful storage of Australian figs at 50°F. and R.H. of 85 per cent. for 21 days; at 40°F. and 35°F. the fruits could only be held for 14 days. Recent investigations have shown that figs can be satisfactorily preserved in their fresh state by freezing and holding in the frozen condition until required (10). By using pony refrigerators it has also been shown that fresh figs can be transported to distant markets (3).

Preservation of fresh figs for export may also be achieved by immersing fruits twice in a special paraffin preparation, whereby a rigid envelope is deposited which preserves the aroma and moisture content and affords protection against mechanical injury. The paraffin coating is removed when the skin is peeled before eating. Paraffin-coated fruits are said to remain in good condition for a considerable time (1, 5).

Brooks *et al.* (2) state that the effect of carbon dioxide has been tested on various varieties of figs with favourable results, mould growth being controlled without injury to the flavour or appearance of fruits.

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Grapes.

The grape vine (*Vitis vinifera*), native to the Mediterranean region, can be grown but does not thrive well in the tropics (1). Kervegant (2), writing of grape culture in Martinique, points out that whereas the vine apparently grows normally, the fruits, instead of ripening uniformly, show progressive or irregular ripening within the bunch, thereby greatly detracting from the commercial value; on the other hand, as Père Labat observed, the grape possesses the admirable quality of fruiting several times a year under tropical conditions. The ripening fruits are very subject to attack by fungi, bees, birds and rats. In general the muscat varieties yield the best fruit in respect of ripening quality, sugar content and bouquet (2).

An extensive literature is now available on the harvesting, packing, physiology, transport and cold storage of grapes. This will not be treated here, but it may be briefly stated that optimal storage temperatures for the several varieties lie in the region of 28°-30°-32°-33°F.; a R.H. of 80 to 85 per cent. is regarded as suitably high to avoid shrivelling and sufficiently low to minimise wastage due to superficial fungal growth. According to varietal and environmental factors, the storage life may range from two to three weeks to four to six months.

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Guava.

Hawaiian grown fruits of the strawberry guava (*Psidium cattleianum*), picked almost ripe, and stored at 32°F. and 36°F., shrivelled and decayed in the course of one month (1). Considerably higher temperatures are considered necessary for the storage of this fruit.

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Jujubes.

According to Popenoe (3), no weather appears to be too hot for the cultivation of the jujube (*Zizyphus* spp.); it has also withstood, without injury, a temperature as low as 13°F. For eating in the fresh condition, jujubes should be picked when the first brown spots appear on the skin. They are then crisp with a sweetish to sub-acid flavour (1). An up-to-date account of the Chinese jujube and the ways in which it can be preserved, stored and utilised has been set forth by Thomas (4). In storage trials conducted by Overholser *et al* (2), jujubes have been kept at 32°F. in open containers for 45 days, and remained marketable for five days after removal. The chief difficulty encountered was the cracking of the skin and wilting. In closed containers, at 32°F., cracking and wilting were lessened, and the fruits kept for 85 days.

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Lettuce.

For proper growth head lettuce (*Lactuca sativa*) requires warm days and cool nights, and for successful storage, low temperature and high humidity (3); leaf lettuce is less suited to handling and is usually used for local consumption. According to Knott (4), quality in lettuce implies that heads are fairly firm (not spongy or soft), fresh and unwilted, well trimmed in respect of old discoloured leaves, and free from decay, tip-burn, bottom-rot, doubles, and other undesirable features. Immature heads, as well as those forming seed-stalks, are to be avoided.

The California lettuce crate, 13 × 18 × 22 inch inside measurement, is slatted and usually lined with heavily waxed paper. The lettuce heads are packed in three layers, sometimes with a layer of crushed ice between. Railcars for lettuce transport are refrigerated, and, in addition, ice blocks or layers of crushed ice are laid over the top of the load, a temperature of 36° to 40°F. being reached about 48 hours after loading (3).

The best holding temperature is generally agreed to be 32°F. with a high humidity. If in good condition when stored, lettuce should retain its eating quality for two to three weeks. If crushed ice is placed around the crates the holding period can be extended several days (7). Excessive refrigeration, *i.e.*, below 32°F., is to be avoided (2). According to Plank and Schneider (5), closely packed slatted cases, lined with oiled paper, in which the heads give mutual protection against excessive wilting, may be held for five weeks at a temperature of 32°F. and a relative humidity of 80 to 85 per cent.

In storage trials with crated lettuce held at 32°, 40° and 50°F., Platenius *et al.* (6) observed the same types of deterioration throughout; at 50°F. the storage life was six days; at 40°F., 20 days, and at 32°F., 30 days. The onset of breakdown was usually indicated by wilting and browning of the outer leaves. The rate of shrinkage was low, being less than 2.5 per cent. during 30 days at 32°F. Some heads which had been kept at 32°F. for six weeks were still firm and of good flavour. Rose *et al.* (8) call attention to the fact that the disease known as tip-burn usually results in a slimy decay during storage; they recommend a temperature of 32°F. and R.H. of 90-95 per cent. to give a storage life of two to three weeks. Initial carbon dioxide treatments, applied as an aid to preservation during cooling to the Big Boston variety, resulted in a withering and discoloration of the outer leaves: the Iceberg variety, on the other hand, was not injured by the same treatments (1).

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Litchis.

According to McGuire (2) fresh fruits of the litchi (*Nephelium litchi*) keep reasonably well at ordinary temperatures for two to three weeks without deterioration in flavour, although the attractive red colour of the fruit may be lost. Refrigerated fruit, on the other hand, showed no loss in colour or flavour during storage for a fortnight. Experimental trials at 40° to 45°F. are suggested. Higgins (1) considers that refrigeration affords the best means of preserving the litchi in its natural state.

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Loquat.

The sweet, slightly acid fruits of the loquat or Japanese medlar (*Eriobotrya japonica*) are prized in the countries where they are grown. No storage data are available.

Malacca Apple.

The transport of the Malacca apple or pomerac (*Eugenia malaccensis*), from Java to Holland in refrigerated chambers at 3°C. (37.4°F.) has been attempted (1). The fruit has no commercial value or reputation on temperate markets.

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Mangoes.

The mango is a delicate fruit and careful observation of certain conditions is essential to its successful storage and transport. Of oriental origin, the mango (*Mangifera indica*) is represented by some 500 varieties, derived in the first instance, as is thought, from six distinct species (2). The relevant literature indicates the following as possessing outstanding qualities of actual or potential commercial importance: Alphonso variety, Bombay (3); Rasapuri and Neelam varieties, India (1); Langra, Malda and Bombay varieties, India (8); the Peters', Bombay or Pairi variety, Jamaica (11, 12, 14); the Julie and Ceylon No. 1 varieties, in other West Indian Islands (14, 15).

In the assemblage of mango varieties, a considerable range of physiological and morphological characters is represented, including differences in size, shape, skin-colour, tendency to sun-colouring, thickness of skin, susceptibility to anthracnose; colour, fibre, sugar and acid content and flavour of flesh; size and shape of stone (15). Among the varieties which have been selected as possible export types, many of these varied characters are exemplified. Surveying mango varieties in general, fruits may range in size from small types weighing 100 grammes to large types weighing 1,000 grammes. Experimental evidence and practical experience show clearly that the behaviour of different varieties in storage, and, in particular, their susceptibility to wastage, are profoundly affected by environmental conditions (15).

Changes during Development.

Early in its development the mango acquires the final shape characteristic of the variety; thereafter, further modifications are slight, though of considerable importance in assessing the stage of maturity as distinct from size alone. In the young fruit, the seed consists of the small white embryo with conspicuous cotyledons attached by a long stalk to the flesh and surrounded by a parchment-like integument. At this stage, the flesh is pale green but becomes white as the fruit enlarges, the first trace of yellow ripening colour appearing when the shoulders (that part of the fruit situated round the stem end) become level with the point of insertion of the stem instead of sloping away from it. Colouring and softening of the flesh is from the seed outwards; at this stage the latter has become surrounded by a cartilaginous and finally, stony endocarp. If allowed to ripen on the tree the later growth developments include the raising of the shoulders, and the elevation of the stem on a small mound surrounded by a hollow. The flesh ultimately becomes deep orange throughout (15).

During development and ripening, important changes take place in the amounts of sugars and acids present in the flesh (1, 15). The acidity rises to a maximum when the fruit has attained about one-third of its final weight, the flesh at this stage being greenish: with further increase in weight the flesh becomes white and the acidity falls steadily. As indicated by Cheema and Dani (3) for the Alphonso variety, the shoulders of the fruit, where localised growth continues until a later stage, provide an indication of the actual maturity reached. The endocarp begins to differentiate at about the stage when the shoulders have become level with the point of insertion of the fruit stalk and simultaneously with this the flesh becomes pale yellow. When the shoulders have become raised the flesh is pale orange and the endocarp fully differentiated, rigid and fibrous. These observations are of value in assessing the maturity of the Julie and other varieties which show little skin colouration (sun colouring excepted) during ripening.

Acidity changes in the Julie variety (picked full-grown green and firm with shoulders raised) during ripening at tropical temperatures and at 47.5°F., have been investigated (15). At tropical

temperatures the fruit becomes ripe and soft after five days and over-ripe after eight days, these changes being accompanied by a striking reduction in acidity: at 47.5°F. the acidity increases during the first nine or ten days of storage, falling to the original value after 13 to 15 days and finally, with prolonged storage, reaching values in the region of those observed in fruit ripened without cold storage. In fruit stored at 60°F. and 50°F., a gradual decrease in acidity during the first 13 and 22 days respectively, followed by a rapid fall, was recorded. These acidity changes at the lower temperatures are of particular interest in view of the fact that 50°F. is close to the critical chilling temperature for this and other varieties.

The ripening data given above for the Julie variety are in general conformity with those published by Banerjee, Karmarkar and Row (1) for the Neelam variety at 37°C. (95°F.) and 27°C. (81°F.). They found that acidity values fell to a minimum after seven days whilst total sugars rose to a maximum. Reducing sugars reached a maximum after 12 days by which time, however, the fruit had become rotten. At the storage temperatures of 10°, 5° and 0°C. (50°, 41° and 32°F.), no appreciable alteration in acidity or reducing sugars occurred in 14 days. At 50°F. there was a rise in total sugars but none at 41° or 32°F. in the same period.

Preliminary estimations have also been made using the Julie variety to determine the regional distribution of acidity (15). These show that there is a marked gradient of increasing acidity from the skin to the stone, which is greatest when the total acidity (as estimated above) is highest and decreases with ripening.

The effect of pre-storage delay on the final acidity on removal from cold storage is considerable. Julie mangoes picked full-grown green, firm, with shoulders raised and stored at 40°F. for seven days followed by 45°F. for 23 days (*i.e.* a total of 30 days) possessed a titratable acidity at the end of this period of 19.6 cc. N/10 NaOH, whereas comparable fruit exposed for two, three and four days to tropical temperatures followed by six, five and four days respectively at 40°F. and subsequently for 26 days at 45°F. (*i.e.* a total of 33 days) required 7.4, 5.5 and 4.5 cc. N/10 NaOH.

Picking Maturity.

Experience has shown that mangoes, over a considerable range of maturity, will eventually ripen if maintained under suitable conditions. For convenience, in the Julie variety, three stages may be defined: grade (*a*), almost full-grown, green fruits in which the shoulders are level with the insertion of the stem-end; grade (*b*), a later stage where further growth has taken place, so that the shoulders are raised above the hollow in which the stem-end is inserted; grade (*c*), in this stage little or no further growth has taken place, but fruits are on the point of becoming soft (15).

The selection of fruits of different maturities is dependent on (i) the duration and temperature of transport and (ii) the presence or absence of cold storage facilities during the distribution period. Where cold storage facilities are available until the day fruit passes into the hands of the consumer, the best results are obtained when fruit of category (*c*) (*i.e.* picked just prior to softening) is maintained throughout at a temperature of 45°F.; the full flavour is thus obtained and wastage is at a minimum. It is to be noted that this class of fruit is not subject to chilling. Where such facilities are not available, fruit should be picked at a stage of maturity intermediate between grades (*a*) and (*b*) the bias being towards the more mature grade (*b*) (15).

The maturity criteria afforded by the relative positions of stem-end insertion and shoulder development appear to be well-established for the Julie variety (15); Cheema and Dani (3) have demonstrated that they are also applicable to the Alphonso variety exported from India, and Smith (12) for the Pairi, Peters' or Bombay mango, exported from Jamaica.

In the Ceylon No. 1 variety, fruits should be picked full-grown with the first trace of colour; as this is a clear-skinned variety, little difficulty should be experienced in effecting the selection of a commercial grade of fruit.

According to the duration of storage anticipated, suitable adjustments of picking maturity between grades (*a*) and (*b*) should be made.

Packing.

The standard 20-lb. tomato lug (5 × 16½ × 17 inch), packed in one or two layers, would appear to be suitable for mangoes (14, 15). The use of single layer trays has also been advocated (15), and in practice has proved advantageous. Smith (12) recommends two sizes, 17½ × 11½ × 5½ inch and 17½ × 11½ × 4½ inch.

In view of the considerable shrivelling to which varieties such as the Julie are subject, wrapping papers should be selected from among those known to have good moisture-retaining properties. The fruits, 25 to 40 per crate, according to size, should be safeguarded from bruising against the slats and sides by the insertion of a light pad of wood-wool. To avoid undue self-heating in packs and the danger of accelerated ripening on removal from cold storage the amount of wood-wool used should be reduced to the minimum (15).

Storage Temperatures and Chilling Injury.

It has been conclusively demonstrated that mangoes are subject to low temperature injury (15). Chilling may be manifested in several ways, including the production of definite skin blemishes, failure to develop normal colour on ripening, failure to ripen on removal from cold storage, and a notable decline in resistance to the inroads of pathogens. Susceptibility to chilling varies with the variety, maturity on picking, season and duration of exposure to low temperatures. Trinidad experience indicates that mango varieties

in general are subject to chilling injury if exposed to temperatures below 48° to 50°F., superficial blemishing being accentuated by partial desiccation, especially where fruits are fully exposed to the action of air-blast refrigeration (15). In normal commercial consignments, where carefully wrapped and packed fruits are stored in bulk, a transport temperature of 48°F. (with delivery air not falling below that temperature) might be adopted where fruit of approximately grade (*b*) has to be held in cold storage during a voyage of 15 to 20 days. Only where fruit picked on the point of softening, grade (*c*), is being handled should a lower storage temperature, 45°F. as already discussed, be used. It is possible that the storage temperature of 48°F. suggested may require modification in the light of further experience, since, admittedly, it borders on the critical temperature for chilling. It is suggested, in preference to a storage temperature of 50°F., for the following reasons:

(i) to offset the effect of ripening during pre-storage delays;

(ii) to allow for possible slow rates of cooling and self-heating in bulk consignments;

(iii) because consignments of fruit, held for upwards of 15 to 20 days at 50°F., have been characterised by severe wastage, this temperature being sufficiently high to permit of considerable activity by storage pathogens (15).

Where only slight chilling has taken place, the effect is largely superficial and not infrequently disappears or is masked by the development of ripening colour. On removal from cold storage to a temperature of 65° to 70°F., fruits which have not been chilled ripen normally in the course of four to seven days.

Where facilities for expeditious transport are available, the shipment of a good class of fruit at temperatures between 50°F. and 60°F. is feasible (15).

During recent years various attempts have been made to ship mangoes from India to the London market. A report by Cheema and Dani (3), published in 1932 and extended in 1933 covers the export of the Alphonso variety from Bombay. It is stated that during the 1931 shipments, crates were stored at 45°F. in the purser's cool room "a temperature which does not cause much injury to the fruit for a period of about three weeks". (Actually the temperature was found to vary from 36° to 45°F.). Wastage due to fungal activity and to physiological disorders is described; from the trade commentaries appended it is evident that more or less severe chilling and high wastage were characteristic of many consignments.

An account of mango storage, using Rasapuri, Neelam and other varieties, has been published by Banerjee, Karmarkar and Row (1). It is evident that these investigators were considerably handicapped in their work by the lack of adequate temperature control. Experimental storage trials at temperatures of 0°, 5°, 10°, 25° and 37°C., however, yielded interesting data on ripening and on the changing concentrations of sugars and acid under the several conditions of storage. Mangoes stored for ten days at 0°C. (32°F.) failed to ripen subsequently; other data showed that exposure to this temperature, even for short periods, is harmful. Given suitable conditions of humidity, a temperature of 0°C. was useful for the preservation of ripe fruit. At 10°C. (50°F.) fruits slowly ripened in the course of 20 days, flavour and sweetness being normal. At 5°C. (41°F.) fruits failed to ripen or ripened abnormally. These investigators accordingly consider that 50°F. is about the critical temperature for mango storage: below this the fruit will not ripen. Among other aspects gas storage, humidity control, the reduction of fungal wastage by various superficial treatments, and preservation in syrups, are considered.

Other Indian investigations of mango storage include those of Gandhi and Cheema (4), and Ram Ayyar and Joshi (8), who obtained satisfactory storage results at 50°F. Attempts at mango transport from Java to Holland are described by Spoon (10), the fruits being packed in coconut fibre and held at 3°C. (37.5°F.), during the voyage of five to six weeks.

In an early report, 1907, Higgins (5) states that mangoes had been held in cold storage in Hawaii with favourable results, while in 1915 Rolfs (8A) refers to the shipment of mangoes from New Zealand to London at a temperature of 45°F. Wilcox and Hunn (16) have briefly described some experiments with Hawaiian mangoes stored at 32° and 36°F.; the pulp remained in good condition for one to two months but the skin acquired a deadened, shrivelled appearance. Higgins and Punzalan (6) have considered the possibility of shipping Philippine grown mangoes to Chinese and Japanese markets. Storage trials at 36°, 40°, 45° and 50°F. indicated that green but fully developed fruits could be held at 36°F. for 18 days; at 40°F. fungal wastage was prevalent, and at 50°F. consignments were marred both by fungal activity and shrivelling. Other writers (13) cite 37.4°F. as a suitable transport temperature.

Recently Smith (11, 12) has described the results obtained in experimental shipments of the Jamaica Pairi, Peters' or Bombay variety to England; the most favourable storage temperature is thought to be in the vicinity of 47°F.

Ethylene Ripening.

Marloth (7) states that ethylene can be used to advantage in the ripening of mangoes, the effect of treatment being perceptible in both skin and pulp. It is not claimed that ethylene ripening alters the "turpentine" flavour of the fruit. The method of application is based on that used in the ripening of grapefruit and oranges. According to another report ethylene did not prove effective in accelerating the ripening of mangoes (13).

Humidity and Loss in Weight.

Losses in weight during storage are chiefly due to transpiration. Varieties such as the Julie may quickly become shrivelled if exposed to relatively dry air, especially at high temperatures. The onset of anthracnose or soft-rots was invariably accompanied by a rapid decrease in weight. The smaller the fruit, the more rapidly is moisture lost through transpiration with concomitant increase in the rate of shrivelling. At 70°F. and with a relative humidity of 75 per cent. (*i.e.* average ripening-room conditions) full-grown fruits of the Julie variety lose approximately one per cent. of their original weight per day. Fruits from different trees may show differences in rate of transpiration irrespective of the actual size relationship, maturity and other factors being involved. Temperature relations are important in determining the extent of water-losses. At 80°F. transpiration proceeds at approximately five times the rate at 40°F. At the low temperatures of storage, loss in weight proceeds steadily, so that, in the Julie variety, fully exposed to air-blast refrigeration during 20 days at 45°F. and 50°F. respectively, losses amounting to 8.1 per cent. and 10.1 per cent. respectively were recorded. In this variety, it has been ascertained that fruits of commercial grades of maturity begin to evince signs of shrivelling when water-loss has amounted to 12-15 per cent. It follows that if, in relation to the method of packing and to refrigeration conditions, considerable losses are sustained during cold storage, the margin of time at the higher (ripening or distribution) temperature during which fruit remains unshrivelled, will be correspondingly reduced. In the Julie and other commercial varieties, storage data indicate the need for wrapping fruit to curtail water-losses.

Wastage.

The wastage problem in mango storage is serious. Quite apart from damage due to wound parasites (which should be inconsiderable in carefully-handled fruit) the majority of mango fruits grown under West Indian conditions, though apparently sound and unblemished on picking, carry latent infections of several important pathogens. Disease incidence during ripening, attributable to such dormant infections, is greatly accentuated by chilling, prolonged cold storage, slow ripening and tardy distribution.

As rotting is almost entirely due to pathogens established as latent infections during growth, the extent to which wastage may be reduced by spraying operations requires careful investigation. Various experiments undertaken by Banerjee, Karmarkar and Row (1) on the efficacy of steeping fruits in disinfectant solutions such as potassium permanganate, formaline, phenol, &c., prior to packing were attended with negative results—a conclusion in keeping with Trinidad experience with other fruits. It is not impossible that a fuller exploration of this aspect may be attended with more favourable results.

The high incidence of field infections directs attention to the need for careful consideration of orchard sanitation, and questions of spacing, pruning, spraying and upkeep generally should be made subjects of special study at the time when orchards are being established.

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Mangosteen.

The mangosteen (*Garcinia mangostana*) is generally regarded as one of the most delicious of oriental fruits. "The combination of beautiful colouring with delicate enticing flavour entitles the mangosteen to rank above all other fruits of the Asiatic tropics" (3). Nevertheless, the mangosteen is still very restricted in its distribution. On the subject of the overseas transport of the fruit, a few experimental records are now available.

An early reference (1906), to the possibility of transporting mangosteens overseas is made by Heyl (2), who described the successful shipment of small consignments from Martinique to France, the voyage taking 12 days; no mention is made of the storage conditions employed. According to another account mangosteens coated with latex were successfully transported from Java to Europe in 1923 (6).

During the years 1927-29, a number of trial shipments of mangosteens were made from Java to Holland, the voyage occupying 33 days. The fruits were packed, 28 per box, with coconut fibre, and stored at 3°C. (37.4°F.). The consignments remained in fairly good condition up to 24 days (examination at Genoa) but had become over-ripe with considerable deterioration by the end of 33 days (arrival at Amsterdam). "The white flesh of the fruit had become grey-brown in colour with a strong odour of fermentation; while the shell of the fruit, which is normally soft and easily cut with a knife, had become stone-hard. Other methods of packing and of storage were tried with subsequent shipments, but in almost all cases equally disappointing results were obtained. In the last shipment, in which the fruits were first covered with rubber latex before shipment, a slightly higher proportion of sound fruit was obtained." From these trials it would appear that mangosteens may be held in good or fair condition for 21 to 28 days (5).

Experimental shipments of Burma grown mangosteens to London have been made from 1929 onwards (4). The fruits were picked (*a*) almost ripe and (*b*) just ripening; in some instances they were coated with rubber latex; the individual fruits were wrapped in unglazed paper and packed in a single layer in cases measuring 18 × 18 × 5¾ inch., each case holding 50 fruits; the cases were lined with newspaper and coarse wood-wool was used as a packing material; the carrying temperature was 50° to 55°F., and the duration of the voyage approximately 30 days. The carrying temperature selected was in relation to previous experience that definite chilling injury was indicated at a temperature of 35° to 38°F.

On being examined in London, the sound fruits, *i.e.* those in which the rind was still soft, and constituting 45 to 60 per cent. of the consignments, were normal in flavour and fresh and attractive in appearance. Fairly severe wastage, due to Diplodia rotting, was present in all boxes. The evidence suggested that a considerable proportion of this was already present at the time of shipment, indicating the importance of grove sanitation (4).

It is probable that during shipment at 50° to 55°F.-the flesh temperature at unloading actually was 60°F.-some increase in wastage took place. The curious feature of rind hardening was almost entirely confined to diseased fruits; it is thought that this may be a secondary effect following some previous fungal or physiological injury, but exact information is required. The latex treatment was effective in retarding the rate of transpiration, thereby preserving the fresh appearance of fruits, but the commercial applicability of this method of conserving moisture is doubtful. Fruits picked when quite mature were superior in flavour but more wasty than those picked "just ripening". The latter, when not protected by a latex coating, were also subject to shrivelling. In general a small fruit pack was found most suitable (4). In a test of keeping quality after arrival, good results were obtained up to five days at 55° to 60°F., but after nine days considerable hardening of the rind was noticed.

Two further shipments of mangosteens from Burma to England have been described (1); in the first, the average transport temperature was 52°F. (range, 38° to 52°F.) during a voyage of 30 days; in the second 53°F. (range 48° to 54°F.), during a voyage of 33 days. On the whole the second shipment, *i.e.*, where a steadier temperature had been maintained, was the better. Wastage on arrival was more than ten per cent. in both shipments. The best fruits in respect of appearance and quality were those which had been picked when almost fully ripe; this is apparently the best picking maturity: fruit picked "just ripening" was of variable maturity on receipt in London; the flesh was generally of poor flavour, rather hard, and in poor condition for marketing; there was evidence that this fruit had not ripened during the voyage. As in the earlier shipments, wasty fruit was characterised by hardening of the rind; this phenomenon was also observed in certain apparently sound fruits. Samples from the second consignment, when stored for an additional week, developed over 50 per cent. wastage.

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THE SPACING OF SUGAR-CANE ROWS.

Some Agronomic and Economic Implications.

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Introduction.

Twelve years ago the writer (41) emphasized that in subtropical countries the harvesting of a large proportion of late suckers, which are usually common in widely spaced cane, however well developed physically, can be just as disastrous in its effect on average sugar content and purity as unseasonably late planting of the fields. This latter effect has been recently substantiated by his investigations of the optimum planting dates for sugar cane in Egypt (44). How deleterious such late suckers are considered in the West Indies may be deduced from the following statement by Saint (45)."

> "Few October shoots made their appearance during 1933 and this probably accounts for the rapid maturity and high sugar content . . . which was noticed during the crop."

In subtropical countries such as Egypt, Louisiana or Tucumán, where cane does not normally have an actual growing season of more than eight months, late suckers cannot possibly reach a satisfactory sugar content and purity and, while adding weight, have an extremely bad effect on the general purity of all the cane at crop time. There is no doubt in the writer's mind that the practice in vogue in these countries of planting much more thickly than is the case in tropical countries with normal growing seasons has arisen from the necessity of having the great majority of canes at harvest of as nearly the maximum age as possible. Nor is there any doubt that the same principle of uniform ripening will apply in tropical countries as well, since were all canes cut at sixteen or eighteen months in Cuba or Puerto Rico of exactly these ages instead of having varying proportions of ten, twelve and fourteen months' cane, the already splendid sugar contents and purities would be surprisingly bettered.

Late Growth and Sugar Yield.

In conducting varietal experiments with sugar cane the writer has for many years made frequent germination counts with numerous varieties and has always been impressed with the high proportion of very young canes—particularly with some varieties—which must be sent to the mills each crop, thus enormously reducing the potential sugar value of the average of the older canes. Some counts (38) on *P.O.J.* 234 cane in comparison with *Louisiana Striped* at the Tucumán Experiment Station in the Argentine Republic some years ago may be pertinent as an example. This cane was planted in July—it will be remembered that the seasons south of the equator are exactly the reverse of the north in point of time and beginning about the middle of September, or two months from the time of planting, a count was made each week of the number of sprouts above ground in one row 100 metres long until the time when suckering began in abundance and further counts were impracticable.

The following table gives the results of these counts for the various dates in terms of sprouts above ground per row of 100 metres, the distance between the rows being two metres.

TABLE I.
Germination Counts.

Date.	Variety. P.O.J. 234.	Variety. La. Striped.
September 18	196	66
Do. 25	331	150
October 2	434	186
Do. 9	496	210
Do. 16	543	224
Do. 23	618	270
Do. 30	701	304
November 6	856	312
Crop. Sept. 6	1,315	564
Canes under 8 ms. age%	35	45

On account of an exceptionally open winter the year these counts were made, there was some germination and development in August, which is not usually the case in Tucumán, and, as growth practically stopped in the early part of June, this cane had the exceptionally long growing season for Tucumán of about ten months. The crop figures, however, compared with the count on 6th November, show that over one-third of the *P.O.J.* canes harvested had less than eight months of actual growth, while almost one-half of the *Louisiana Striped* was below that very immature age.

Cross (11) made some interesting analyses of canes from the same field at intervals of one week, beginning when the stubble was approximately eight months old, and these show very graphically the values to be expected, comparatively speaking, from cane at different ages, as well as the effect which must irretrievably follow the harvesting of canes in various stages of immaturity. The writer has selected from Cross' voluminous figures bi-weekly analyses of the *P.O.J.* 234 variety at the ages indicated in Table II.

TABLE II.
Ripening of P.O.J. 234 Cane in Tucuman. Third Ratoons Juice Analyses.

Age months.	Brix.	Sucrose.	Glucose.	Purity.
8	17.07	14.90	0.57	87.33
8.5	18.38	16.11	0.45	87.64
9	18.38	16.22	0.29	88.24
9.5	18.27	16.59	0.13	90.80
10	18.75	17.17	0.13	91.57

If the analyses of the *P.O.J.* 234 in Table II are compared with the figures given in Table I, showing the proportion of canes of the different ages indicated above which may be normally expected in a field of subtropical cane, it is easy to visualize the effect of either decreasing or increasing this proportion of immature cane. Undoubtedly if by any means we can increase the average age of the canes harvested from any field we will have correspondingly increased the average sucrose content of those canes, while, conversely, if this average age is reduced through prolific midsummer suckering there is no possible way in a subtropical country of avoiding a corresponding lowering of the average sugar value of those canes.

The "Light and Air" Theory of Spacing.

Advocates of extremely wide spacing of sugar canes have always insisted on the dependence of cane on large amounts of light and air, the same idea that evidently animated Newlands (34) when in 1869, in his then standard treatise on sugar cane culture, he wrote:

> "The importance of constant trashing cannot be too strongly insisted upon, as it admits to the plant that abundance of light and air which is absolutely essential to the production of a heavy crop of sugar."

The abandonment of this very process of periodical stripping off of the lower leaves of the growing cane, which was formerly so much in vogue in Hawaii, Puerto Rico and Queensland, points very strongly towards the fallacy of such extreme wide-spacing recommendations. One of the most useful accomplishments of the experiment stations of those countries has been to demonstrate not only the uselessness of that method of admitting light and air to a plant which stands in no need of such large quantities of those elements *for the stalks and lower leaves*, but also the actual damage and financial losses which it has caused.* Inasmuch as the processes incident to the conversion of plant food into sugars are carried out largely in the newer and upper leaves, there would seem to be no good reason for going to the expense of admitting more light and air to those parts of the plant which do not require them in such abundance, to say nothing of the actual damage frequently caused when this process of stripping is employed through injuries to the cane by plucking leaves still performing their laboratory duties.

Eckart (17), in three exhaustive series of experiments at the Sugar Planters' Experiment Station in Hawaii, thoroughly demonstrated the uselessness of and financial loss from, stripping in Hawaii, finding that the percentage of sucrose was higher in the juice of the unstripped canes, that the unstripped canes gave considerably higher tonnage yields in the field than the stripped canes, and that, at harvest time, there were always considerably more dead canes in the stripped than in the unstripped plots. In other words, stripping was definitely detrimental. Since the publication of Eckart's experiments stripping in Hawaii has been practically abandoned.

Crawley (10) carried out a number of stripping experiments at the Insular Experiments Station of Puerto Rico from 1912 to 1914 and concluded that stripping caused "a waste of time and money". Guanica Centrale, about the same time, conducted several experiments in the San German Valley, where at that time it was the general custom to strip all canes to determine the results of stripping from a sucrose and purity standpoint. In each of these experiments it was found that the juice from the unstripped cane was higher in sucrose and purity than that from the cane that had been stripped. In a letter received from the management, it was stated:—

> "We do not believe that any benefit is derived from the stripping of cane, and are convinced that a good deal of injury may be caused to the cane by the injudicious tearing off of the green and partly dried leaves* . . . We, some years ago, issued a standing order that this work was to be discontinued on all of our properties, and I am sure that we have lost nothing by so doing. On the contrary, we have saved an annual expenditure of an average of about $2 per acre, the price usually paid for this class of work, over a total of about 15,000 acres in cultivation by this company, or a total of $30,000 per annum."

This letter is but indicative of the general abandonment in Puerto Rico of the process of "admitting light and air" through stripping.

Another interesting case in this regard is that of Queensland, whose sugar planters' main protest against the much discussed "white Australia" legislation was based on the ground that white men were incapable of carrying on the onerous and necessary work of stripping the cane. It was found, however, that the abandonment of this process not only failed to lower the yields of cane and sugar per acre, but saved the sugar men a a considerable sum which they had until then been spending on an entirely useless and largely ornamental system.

Since stripping and extremely wide spacing had the same fundamental objective of admitting additional light and air, it would appear that the demonstration of the negative value of stripping had also established the fallacy of extraordinarily wide spacing of cane. Nevertheless in 1924,

*Boname (7) in 1888 published some experimental results tending to show that where only the entirely dead leaves were removed in Mauritius an increase of about one point in the sugar content was obtained, but where, as was usually the case, a goodly number of rather green leaves were also torn off, a corresponding drop in sugar content, as compared with untrashed check plots, took place.

*Deerr (14), stating that the premier alleged reason for the process was the exposure of the cane to the effect of light and air to hasten maturity, concludes:

> "The ripening effect is small and the damage done by the labourers passing through the fields more than offsets any possible advantage . . . particularly when other than quite dead leaves are removed, as then the way may be prepared for the attack of fungi."

ten years after the publication of Crawley's categorical results, we find Calvino (9) in Cuba advocating the "Abreu system" of planting in holes twelve feet apart and Hind (23) in the Philippines writing:

"The hole (10 feet apart) method of planting admits more light and air to the stools, which, doubtless, has a beneficial influence on purities."

Hind furnishes no data from experiments which would indicate that this statement is anything more than an opinion, whereas experiments carried out in Louisiana by Stubbs, in Cuba by Earle (16), and by eminent investigators in other countries, have rather definitely proved that wide spacing and the admission of light and air do not by any means necessarily signify improved purities and sugar contents of juices. Some of these experiments will be discussed below.

The "Abreu system" is nothing more or less than the old "Zayas system", which Earle some thirty years ago demonstrated to be thoroughly impracticable in Cuba where it was then quite popular, with the addition of the two very impracticable features of still wider spacing and pre-planting seed germination. After careful trial he found that not only were the yields considerably less than from cane planted at a normal distance, but also that the expense was vastly greater. Naturally, at such a distance cane would never close and constant cultivation would be required throughout the entire year to keep down weeds and grass. The worst feature of the system, however, according to Earle, was that the cane was *not sufficiently shaded*—in other words it seems to have had a plethora of "light and air". It suffered severely from sunburn and "especially on old worn soils, it failed to ratoon well, these plantings going out earlier than those at normal distances" an important consideration and the substantiation of an observation often made by the writer, *i.e.*, that very widely spaced cane runs out much more quickly as a general rule than cane planted at more normal distances, thus again demonstrating that sugar cane is a "sociable" plant.

As to subtropical countries, Cross (11) has recently published some strikingly illuminating data obtained from experiments comparing the results from the planting of *P.O.J.* canes in holes and in furrows, the holes being the same distance apart as the furrows normally employed in the Argentine (metres 1.70 to 1.80). Not only did the hole-planted cane produce only 43 per cent. as many harvested stalks per row, at the first crop, but their average weight, due to the large proportion of suckers, was only two-thirds of that of the canes from the normal row planting, with the result that the latter produced well over three times the tonnage of cane and almost four times as much sugar per acre as did the cane planted in holes. The comparative juice analyses certainly lent no colour to the hypothesis that additional light and air result in richer canes any more than they produce sugar beets of higher sucrose content, judging from recent studies by Lindner (32), Dahlberg (12), van Ginneken (20), Jensen (24), Brewbaker (8), Decoux, Vanderwaeren and Simon (13) and Lavis (28), of the influence of stand on the yield and composition of this other important sugar crop.

Cane Spacing Experiments in Various Countries.

The classic distance experiments of Stubbs (46) in Louisiana with *Purple* and *Striped Cheribon* canes were initiated in 1888. Table III gives his composite results from eighteen crops and shows that the 90 centimetre-rows gave uniformly the best tonnage and the most widely spaced, the poorest. It is notable, too, that the latter have produced cane juices of the lowest total solids and sucrose content and purity and the highest invert sugar ratio. Having in mind the necessities of mechanical cultivation of cane, in which Louisiana was a pioneer, Stubbs concluded that the logical procedure indicated by these results was to select the *narrowest possible spacing consistent with the facile entrance between the rows of adequate cultivating implements.*

Table III.

Composite Results of Early Louisiana Experiments.

Width (between rows.) Metres.	No Stalks. Hectare.	Av. weight Cane per		Chemical Analyses of Juices.				No. Crops.
		Stalks. Grams.	Hectare. Met. Tons.	Brix.	Sucrose.	Glucose.	Purity.	
0.90	75,010	1300	85.0	14.2	10.7	1.53	75.35	14
1.20	68,150	1250	79.2	13.9	10.4	1.62	74.82	14
1.50	69,800	1300	82.5	14.0	10.6	1.54	75.72	18
1.80	66,334	1300	82.1	14.0	10.7	1.66	76.43	12
2.10	66,371	1250	82.0	14.3	11.0	1.66	76.92	6
2.40	62.286	1350	78.1	78.1	10.3	1.72	74.64	6

Up to the time of these experiments, most Louisiana planters employed rows 6 ft. apart, but 5 ft. rows (Met. 1.50) were almost universally adopted after the results of these extensive tests had been published and discussed by Stubbs.

In Hawaii, Blouin (5), after his 1901 experiments with the Lahaina (*Caña Blanca*) cane, planted at 4, 5, 6 and 8 feet, showed that the 5 feet rows produced 60 tons more cane per hectare than the 6 feet ones, concluded that the Hawaiian planters who almost invariably employed 5 feet rows, had no reason whatever for deviating from this practice. Reynoso (36) gives the ideal distance for Cuba as 5½ feet and Boname (7) concluded that 4½ to 5 feet was best for Guadeloupe.* Large sub-station experiments made under the writer's (40) direction in Tucumán province, Argentina, with *Cheribon Striped* and *Purple* at 5, 6, 7 and 8 feet, showed by far the best yield for the 5 feet rows, which gave 24 metric tons more cane per

*In Natal the average distance between the cane rows is Met. 1.50 and in Peru (42) Met. 1.35. Fowlie (19), after trials of both *P. O. J.* 2725 *and P.O.J.* 2878 at Metres 1.20, 1.50, 1.80 and 2.10, has recently stated, "The spacing experiment seems to indicate that . . . the closer the lines are spaced the heavier the yield."

hectare than the 6 feet ones, and a gradual decrease in yield per hectare as the rows were placed farther apart, the 8 feet rows giving by far the smallest yield. A calculation of the financial gain, always the prime consideration in any agricultural experiments, with the 5 feet rows over those of 8 feet based on the price of cane to the planter at the time the experiments were made (1913) showed an advantage of $168 m/n per hectare.*

In 1917, 1918 and 1919 the writer (39) conducted a large series of experiments covering some 50 hectares on the Santa Ana estates, which he was then superintending, in the province of Tucumán, near where the above mentioned sub-station distance experiments had been located, with 5, 6 and 6 2/3 feet middles, the 5 feet rows averaging over 20 tons more cane per hectare per annum than the wider spaced rows. These experiments were made with the Java seedling, *P.O.J.* 228. The sub-station tests at Monte Bello and the Santa Ana tests, being both on a very large scale and in the same district, may quite properly be averaged, the results for the 5 and 6 feet rows being shown in Table IV.

TABLE IV.

Average Results from Four Crops at Monte Bella and Santa Ana 1913-17.

Width Metres.	Middles Feet.	Metric Tons Cane p. Hect.
1.50	5	55.7
1.80	6	42.8

Experiments at the Tucumán station were commenced in 1910, under the direction of R. E. Blouin, and continued by the author until 1916. Since then Dr. W. E. Cross (11) has continued the experiments up to the present time. The first series, with rows 1.20, 1.50, 1.80, 2.10 and 2.40 metres apart, for *Louisiana Purple* cane, was carried through second year cane. The M. 1.20 rows produced the largest tonnage of cane and the two widest spaced series by far the smallest. Blouin (6) concluded from the results of these tests that, *considering the important question of proper mechanical cultivation,* the distance between cane rows in the province of Tucumán should not be less than 5 feet nor more than 6, recommending 5½ feet (M. 1.66) for that type of cane.

About this time, however, the heavily-stooling, rapid-growing and somewhat frost-resistant Java canes, *P.O.J.* 36, 213, and 228, had begun to attract wide attention in the Argentine sugar district and in 1915 the author (37) commenced a series of distance experiments with the *P.O.J.* 36 variety. The following year another series was initiated with the *P.O.J.* 213, a variety of very distinct type of growth from the *P.O.J.* 36, the latter being much more erect and having much less tendency to lodge late in the season in times of heavy rainfall. In 1916, also, experiments were begun with the *Uba* and with another "Japanese" type (*S. sinense*) of cane known as *Zwinga.*

The *P.O.J.* 36 tests were carried through fifth year cane and the others through fourth year, the average results from the seventeen crops showing a slight cane tonnage advantage for the narrower spaced rows. Again, planting distance seemed to exert no appreciable influence on juice quality and Cross (11), reviewing these experiments from the time of their inception a decade previous, arrived at conclusions identical with those of Stubbs already mentioned, viz.:—

> "Summing up the results of all these experiments, it would appear that in order to obtain most economically the largest quantities of cane and sugar per hectare, the distance between the rows should be the minimum that will permit of adequate cultivation with implements."

In Queensland, too, the fetish of mechanical cultivation is probably responsible for the fact that the standard planting distance is still 1.35 metres, although the experiments of thirty years at the MacKay Sugar Experiment Station have shown, in the words of Keogh, (26) that:

> "In all these trials reduced spacing between rows showed to advantage in return of cane and sugar per acre . . . Therefore, with the present width between rows the land is exposed to the drying action of the sun and wind . . . and narrower widths between rows would be an advantage."

Weed Control and Soil Stirring.

The present century has witnessed enormous modifications in both theory and practice as applied to cultural operations in the cane field, due largely to the fact suggested by Agee (2) that increasingly in this generation *The Sugar Planter Looks at Botany.* Outstanding amongst these developments are the gradual reshaping of ideas concerning the necessity of soil stirring in cultivation and the wider adoption of mechanical methods of accomplishing this purpose. In figuring the economy of mechanical over manual cultivation, however, the progressive occidental planter of to-day may sometimes forget that he is cropping far less than the optimum number of rows per acre, and that with those rows more closely spaced the cane would close in much more quickly and thus automatically eliminate the necessity of several of his late mechanical cultivations—and one or two hoeings.

Closely related to the question of frequent soil stirring is that of root pruning. Everyone concerned with sugar cane cultivation has observed that cane several months old always shows visible temporary signs of distress from the root tearing incidental to anything but the most superficial of cultivation. In this connection it is interesting to cite some observations made by Agee and Naquin (1) in Hawaii, which demonstrate the extent of the root system of even very young cane and the danger of impairing it through careless use of implements when practising deep

* In 1913 the Argentine paper peso was worth 8½ *piastres* (42½ U.S. cents).

cultivation too late in its stage of development. By means of a clever method described in Bull. 127 of the Kansas Experiment Station, the root systems of sugar canes were buried in such a manner as to preserve the original positions of the roots. Quite contrary to the usual supposition, it was found that cane of less than three months growth had developed roots intermeshing between rows 1.1/2 metres wide and generally distributed throughout some 38 cms. of cultivated soil depth, some of the roots penetrating as far as 75 cms. into the soil, half of which showed no evidence of having ever been artificially stirred. From these observations it is concluded :—

> "It would therefore seem that cultivating implements cannot be employed to best advantage without due consideration of a root growth such as is illustrated. *The stirring of the surface soil about growing cane would seem almost inevitably to result in more or less root destruction.* When the benefits of stirring the surface soil are such as to more than compensate for this root injury—well and good. However, it is important to bear in mind that counteracting influences are at play, so that care must be taken that the ill-effects do not offset the desired ends."

These observations have been confirmed and similar conclusions reached in almost all of the cane-growing countries by Lee (29) and Weller (31) in Hawaii, Jensen (25) and Gonzalez (21) in Cuba, Venkatraman and Thomas (48) in India, Lee and Medalla (30) and Bissinger (4) in the Phillippines, Hardy (22) in Trinidad, Kulescha (27) in Java, and others. All indicate that the main consideration in stirring the soil around growing cane is the control of the weeds competing for the cane's food rather than that of rendering this food more available to the cane through fineness of division of the soil in which its roots are developing.

Investigations into the theory and practice of maize cultivation, which is correlated to that of cane as far as these particular points at issue are concerned, also point to the same general conclusions, the illuminating work of Gates and Cox on "The Weed Factor in the Cultivation of Corn" being of particular interest in this connection. This was carried on for six years, during which no less than 125 experiments were harvested and the results studied. The general average of all of these showed that weeded plots (weeds simply cut off with hoe at surface of ground without stirring soil) produced 95 per cent. as much fodder and 99 per cent. as much grain as actually cultivated ones—a strong indication that weeds control is, indeed, the prime object of cultivation.

Dense Populations and Cheap Labour.

For a great many years the writer has been very much impressed by the fact that, with the exception of Puerto Rico, the occidental sugar countries space their cane rows much wider apart than is justified by their experimental evidence* and agronomic philosophy, the only explanation of this apparent anomaly being the alleged necessity of having the spaces between the rows sufficiently wide to admit of mechanical cultivation. Against this one advantage of cane rows wider than the agronomic optimum established for each region and the additional one of some economy in seed cane, it has always seemed to him that the following advantages of closer spacing should be more generally taken into consideration :

1. Fewer cultivation operations as the result of quicker closing in of the cane and the consequent check on weed growth, the suppression of which would seem, in the light of modern investigations, to be the principal object of cultivation *per se.*
2. Conservation of moisture due to reduced evaporation.†
3. Minimizing losses due to deficient germination inasmuch as the area of gaps is lessened.
4. More stalks per acre.
5. Less suckers.
6. In countries of heavy precipitation, additional protection to soil from packing effects of beating rains.
7. In subtropical regions, additional frost protection, as is evidenced by the fact that the same degrees of cold injure the extremely closely spaced *P.O.J.* canes in Egypt far less than the same varietal types planted twice as far apart in Louisiana or Argentina.

When in Puerto Rico the writer was much impressed with the fact that the narrow spaced (Met. 1.20 to 1.35) cane fields of that island, in many cases in continuous cultivation for a century or more, consistently produced more cane per acre than the very widely spaced plantings on almost virgin lands in Eastern Cuba. A few years later he found in the Philippine Islands that cane was commonly planted at 90 to 110 centimetres (in the 1932-33 Report of the Research Bureau of the Philippine Sugar Association one metre between the rows is stated to be the optimum, closer planting showing a higher germination loss than wide spacing, but giving the higher yield), while cane with rows as close together as 60 cms.

*Webster (49), reviewing this question in 1931, arrived at the conclusion that the narrow rows tend to give larger yields than the wider ones, but that for economic reasons few countries employ narrow rows.

†McIntosh says (33) in his report on a visit to the West Indian island of Antigua : "Spacing is appreciably closer than in Barbados . . . the plants close in more quickly and prolong their growth further into the low-rainfall crop season . . . even under conditions of comparable rainfall in both islands. The foliage remains comparatively green even under low rainfall conditions. This earlier growth leads to earlier *cane-stool* formation in Antigua. This feature coupled with the closer spacing would appear to effect a suppression of late tillering and late cane formation. The bulk of the crop is made up of early formed canes. As a result varieties . . . which in Barbados, owing to the . . . wider spacing, form a considerable bulk of their crop from late canes . . . in Antigua ripen appreciably earlier."

is common in India. In Formosa and Java (42) he observed that the rows were commonly 105 cms. apart, seldom spaced wider than 120 cms. and, as a result of recent experimentation, the tendency is to reduce the spacing still further, as witness the last report of Demandt (15) in which he states that not only do the narrow spaced rows (105 cms.) give better tonnage of cane and sugar than wider ones, but that results of tests on spacing *in the row* favour more rather than fewer sets. Furthermore, the trend in Java for several years has been toward narrowing down the Reynoso ditches, Demandt now recommending but 25 cms. in light and medium soils and 30 to 35 cms. in heavy lands.

True it is that in all of the above-mentioned cane countries where narrow spacing is in vogue, labour is abundant and, with the exception of Puerto Rico, very cheap, in comparison with that of most of the more thinly settled occidental countries which employ wider middles and more mechanical cultivation. Under these distinct conditions the response to the need for economy has taken the line of more mechanization in the western countries, with the idea of reducing cultivation costs *per acre*, and in the eastern ones the trend has been towards increasing yields per unit of area by maintaining as heavy a cane population as is possible. In the latter case, particularly under peasant systems, the economy arises as the result of the replacement of hired help by family labour recompensed by higher yields.

Conclusion.

It is obvious therefore, that the search for economy has followed distinct trails as a consequence of local labour conditions to a very great extent—and that these directions were largely fixed at the time of establishment of the various local sugar industries. One who has for years observed these two divergent trends in cane spacing is inclined to wonder if precedent may not have been too pre-eminent in establishing this particular phase of cultural practice in occidental cane fields. Might it not be possible that the western cane grower, by maintaining wide spacing between rows to admit of cultivation by heavy implements may be to a certain extent defeating his own purpose of economy by raising his cost of cultivation *per ton*, while reducing it *per acre*? Is he, in his desire for mechanical cultivation, spacing his rows so far apart, that more middle cultivations and even more hoeings must be given than would be necessary were the cane allowed to close in earlier and, by shading out the weeds, automatically render these additional cultivations unnecessary? Why are no more hoeings necessary in the closely spaced Egyptian cane rows than in Louisiana or Argentine, with 100 per cent. wider spacing and far later closing and which produce less than half the average yield per acre than the cane fields of that ancient land? No definite answer to these questions is possible until carefully controlled comparative trials, with an eye particularly on the economic phases, are conducted over a series of years in several of the regions where wide or narrow spacing has for so long been followed.

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REVIEWS.

MANUAL OF THE GRASSES OF THE WEST INDIES.

By A. S. Hitchcock. Misc. Pub. No. 243, U.S. Dept. Agric., Washington, 1936, pp. 439.

This is a book which will come as a great boon to many people, botanists and agriculturists alike, to whom the identification of grasses has hitherto been a matter of considerable difficulty, either through lack of suitable references or from inability to make satisfactory use of those which exist. To a great majority, naming a grass is not a task to be undertaken lightly, and is greatly assisted by (if not entirely dependent on) illustrations of the habit and spikelet characters of the species. In this respect the present contribution, which contains beautiful line drawings of at least one species of each genus, is a marked improvement on its predecessor—"Grasses of the West Indies" by Hitchcock and Chase—now some 15 years old. In addition, the new work has considerably extended the descriptions of the species, which, with keys to the tribes, genera and species as additional aids, are now very fully treated. The general arrangement and printing of the book are excellent.

In bringing this work up to date, new or revised species have been included from recent collections in the United States National Herbarium, mainly of grasses from Cuba and Hispaniola; the range of distribution of some of the previously recorded species has also been extended thereby. Furthermore, monographs on individual genera or tribes (the author's own work supplying a not inconsiderable proportion of such information) have had to be consulted with a view to correcting nomenclature and synonomy. From the general user's point of view, this is the least satisfactory aspect of a new edition of any systematic work, since it so frequently involves the alteration of names of the commoner plants, grown familiar through long usage. The present case is unfortunately no exception in that respect, and from a casual glance there are at least three well-known Trinidad grasses which have suffered at the hands of the systematist: "Gamalote" (previously *Chaetochloa sulcata*) becomes *Setaria poiretiana*; "Corn grass" (previously *Manisuris exaltata*) becomes *Rottboellia exaltata*; and "Para grass" (previously *Panicum barbinode*) becomes *Panicum purpurascens*.

It would be ungrateful to conclude this brief review on what might seem to be a deprecatory note. This volume will persist as a lasting monument to one who, more than any other man, has made permanent and practical contributions to our knowledge of American grasses. Few territories have had greater cause to regret Mr. Hitchcock's recent death than the West Indies, which has reaped a full harvest from the widespread researches and collections of a botanist of world repute.

N. W.

JAMAICA.

THE BLESSED ISLAND. By Lord Olivier, *Faber and Faber Ltd.*, London, 1936, pp. 466, *Price* 21s.

Written by an enthusiast in his subject, "Jamaica" is essentially a social, political and economic history of the island from the suppression of slavery to the present day. The text is divided into four parts, of which the first, occupying some fifty pages, is given to an introductory survey. This is well done, and contains an outline of Jamaican history, followed by a rather more detailed physiographical survey of the island (rendered easily assimilable by a folding map on a generous scale at the end of the book), which provides a backcloth for the events dealt with in later sections. Book I closes with a chapter on conditions preceding emancipation which serves to raise the curtain on the Jamaica of 1800 to 1837. The second part takes up the story after the emancipation of slaves (1838) and carries it to the "Jamaica Rebellion" of 1865, under the suggestive title of "The Dark Age". An account is given of religious influences on the newly-freed population, and is followed by a discussion of the results of emancipation, of which the most significant was the migration of labourers from the sugar estates to the hills, to establish and manage small holdings of their own. In a later chapter a description is given of the destitution resulting from the depression in plantation agriculture in the years around 1850, which, with the recent world-wide slump still fresh in the reader's memory, can all the more readily be appreciated. The third book mainly records the most noteworthy points in the administration of the governors from 1866 to 1897, and gives the opinions on the inhabitants of the island expressed by visitors and witnesses before the Crossman and Norman commissions.

For those whose experience of the British West Indies is entirely post-war, the contents of Book IV, which occupies rather less than half the volume, are of paramount interest. Most of the problems dealt with are West Indian rather than Jamaican, and to varying degrees are present to-day in most of the islands. In a chapter entitled "Land and People" an interesting sketch is given of land tenure and settlement, throughout which the author shows his sympathies with a scheme of agriculture based on small freeholders employing co-operative methods. The author recommends that careful consideration be given to a policy of forest conservation as a means of checking artificial denudation and consequent erosion. The need for such a policy would seem to be immediate after a perusal of the chapters on water supply, the periodical vagaries of which have been responsible for hardships since the earliest times.

Education is dealt with in a single chapter, this being primarily concerned with its history and present status. The story of educational development as far as 1880 makes a sorry tale, but the present provision for juvenile training and discipline indicates that a conscientious endeavour to put this public service on a sound footing is steadily overcoming the obstacles to progress. It would have been interesting to learn the author's opinion regarding a curriculum for use in the rural districts, where the question of framing education to suit the needs of the rising generation of small-holders is pressing for solution.

Of the exports of Jamaica none is so widely known as the banana, and the outstanding features of the development of this trade with the United States, Canada, and Great Britain are presented in an entertaining chapter on the Banana War, in which the commercial campaigns waged for the past seventy years are condensed into an invigorating account of seventeen pages.

A brief outline of the undertakings sponsored by Government in the public service, followed by a description of the form of the Island constitution, complete the informative chapters, with the exception of a brief recapitulation of general principles with regard to the Island and its outlook.

The book closes with a bibliography containing over forty references, followed by an index. It can be commended to all interested in the ways of life of Antillean citizens, since the statements and conclusions are applicable over a wider area than the title of the book might suggest, and afford a sympathetic presentation of the outlook of the agricultural element in the population of the British West Indies.

R. G. F.

* * *

A HANDBOOK OF STATISTICS FOR USE IN PLANT BREEDING AND AGRICULTURAL PROBLEMS.

By F. J. F. Shaw, C.I.E., D.SC., *Imperial Council of Agricultural Research*, Delhi, India, 1936, pp. 182, price 7/3.

As the author explains in his foreword, this book is not a mathematical treatise on statistics but a simple exposition of the *application* of statistical methods in biological research. It is written for the student, the plant-breeder and the agriculturist as an easy guide to the correct statistical interpretation of experimental data. The ground covered is extensive and includes discussion of frequency distributions, the probability integral, correlation and regression, the calculation of linkage values, and the analysis of variance and co-variance in field experiments. The statistical technique applicable to any particular problem cited is illustrated by excellent examples from actual experiments carried out in India and Burma. The fundamental statistical tables for the interpretation of experimental data are reproduced in the text or in the appendix.

As with most first editions of books of this type composed largely of complex tables of figures and of rather intricate calculations and formulae, there are a few minor typographical or other errors. However, the standard of the printing as a whole is admirable, and the dove-tailing of the tables and calculations into the descriptive

text is very praiseworthy. The use of a wide page has been partly responsible for the first class quality of the publication in this direction. The publishers are to be congratulated on excellent workmanship, which greatly facilitates the ease with which the statistical procedure can be followed.

In attempting to produce, in a single volume, an introduction to applied statistics for the University student and a simple guide in statistical technique for the research worker, the author has of necessity rather detracted from the value of his book in regard to the second objective. As a practical guide, the description at some length of the alternative methods of tackling various problems must be thoroughly confusing to the novice, especially as an opinion regarding the best method to apply is rarely expressed. Moreover, some of the alternatives discussed have been largely superseded and could have been omitted altogether with advantage. The chapter dealing with the analysis of variance and co-variance in field experiments is rather disappointing. This section deserves much greater elaboration than has been accorded to it. For example, from the analysis of a simple lay-out, the author proceeds directly to a description of a very complex one. In the analysis of co-variance, no attempt has been made to show how the co-variance for error should be applied to the adjusted treatment means. Moreover, the statistical procedure utilised has already been improved upon. It is particularly easy, however, to criticise a book of this type in which an attempt has been made to reduce a highly technical subject to simple terms and yet deal with it in a comprehensive manner. As an introduction to biometry for the elementary student, it is a book that can be thoroughly recommended and fills a very obvious gap in the available voluminous but rather too technical literature on the subject.

D. D. P.

* * *

MOISTURE AND FARMING IN SOUTH AFRICA.

By W. R. Thompson, South African Agric. Series No. 14. *Central News Agency Ltd.*, South Africa, price 21*s*.

Moisture is unquestionably the dominant factor in the production of crops and animal products in South Africa, and the irregularity of the rainfall has a very direct bearing on the success or failure of the South African farmer. By his painstaking study of the rainfall in the Union, the author has cleared the ground for the proper appreciation of this important problem. He is able to show, for instance, that the frequently reiterated statement that South Africa is getting drier has no basis on facts. A careful study of the 'smoothed' rainfall curves shows fairly pronounced secular variations, but, in spite of a more or less definite, though irregular downward trend over the last 40 to 50 years, it is the writer's opinion that there is no proof of any permanent diminution of rainfall.

The author then discusses the way in which the rainfall is dissipated, and suggests as a rough general average, that of the total rainfall received, 50 per cent. is transpired by the crop and the balance is lost in run off (15 per cent.) and evaporation (35 per cent.). None of the rainfall percolates into the sub-soil. These figures are based on experimental work at the Pretoria University Experimental Farm, which admittedly has not been carried on for very long, but they are most suggestive.

A chapter on veld burning indicates the diversity of opinion held about this practice, but holds out the hope that the research now being applied to the problem may show how it may be solved.

The author rightly stresses the way in which man's interference with the vegetal cover has decreased the efficiency of the rainfall by increasing the percentage of run off, and indicates what steps are necessary to remedy the present serious situation. The real value of his work however is that it substitutes observations and records for popular theories, as a basis for the correct appreciation of an important problem.

R. C. W.

* * *

SOIL CONDITIONS AND PLANT GROWTH.

By Sir John Russell, *Longmans Green & Co.*, London, Seventh Edition 1937, pp. 655. *Price* 21*s*.

This well-known book has been issued in seven editions during the past 25 years, which implies not only that the science of plant growing has developed very rapidly, but also that there has been a constant demand for information of the sort contained in this volume. Sir John Russell's long connection with the Rothamsted Experimental Station as its Director, and his mastery of the art of lucid expression, command the attention of students, who will find, as the reviewer has found, never-failing inspiration in his writings, and particularly in his book "Soil Conditions and Plant Growth".

There is no need here to set out the aims and objects of the work more than by the title, nor to indicate its general scope. All students of crop ecology are well aware of the nature of the subject matter, as also of the fact that Sir John Russell has been able to avail himself of the co-operation of his staff of specialists, as well as the librarians of the Rothamsted Station and the Imperial Bureau of Soil Science, in reviewing the latest developments of the several sub-branches of his subject. His successful achievement in welding all this subject matter into a very readable and well-balanced account places students greatly in his debt, and his judgment, selection and guidance may be accepted with full confidence. No agricultural library should be without a copy of each of the seven editions, for within their pages is set out the modern history of agricultural science.

F. H.

LEPIDOPTEROUS PESTS OF THE SOUR-SOP IN TRINIDAD.

(2) *Thecla ortygnus* Cramer.

By R. G. FENNAH.
Department of Entomology.

Distribution and Status.

According to the Biologia Centrali-Americana, *Thecla ortygnus* Cramer (Lycaenidae) is found in Guatemala, Mexico, Costa Rica, Panama, Trinidad and the Amazons valley to Guiana and South-East Brazil, and is a "species sparingly, though very widely distributed in Central America, but in South America it spreads over the whole of the tropical portion as far as South Brazil. Its altitudinal range extends from sea level to a height of 3,000 to 4,000 feet" (1). This species is not recorded among the Lycaenids listed by Kaye and Lamont in the "Lepidoptera of Trinidad".

In Trinidad the insect has so far been observed only on sour-sop, on which it is a minor pest, though little attention has been paid to other likely hosts. References to this species are meagre, and as yet the writer has found no evidence to suggest that it is troublesome elsewhere.

Incidence and Damage.

The intensity of attack varies greatly from tree to tree at any period of the year. It was noted in February and March 1936 that larvae were fairly common wherever sought, and during the last week in March one tree was found with all its flowers attacked, with only one exception. In April 1937, on the other hand, the same tree was free from infestation while trees a few hundred yards to windward had a floral infestation at one time reaching 80 per cent.

The chief damage caused by this insect is destruction of the flowers. Normally the flower opens for a short while, after which the perianth drops to the ground, the carpels develop in size, and the stigmata separate. When attacked by *T. ortygnus* the tissues of the perianth—especially those of the inner whorl—rapidly become blackened around the area eaten or even scarred by the insect. In the laboratory the flower appears to be very susceptible to mechanical injury and drying agencies, and it is likely that feeding of the larva causes premature opening of the bud. In addition to feeding on the perianth, the larva, usually when fairly well grown, eats the upper portions of the closely-packed stamens or stigmata, and if the outer tissues become desiccated before it has reached full size, it frequently attacks the receptacle and may devour it almost completely. Flowers damaged by larval feeding usually fail to develop. Larvae have been observed to attack young fruit, though this type of damage has not been found to be more than occasional. In one case a sour-sop 35 mm. long was found with two larvae inside, both almost fully grown. Fruit attacked at so early a stage falls soon afterwards.

Life History.

The Egg.

When laid, the egg is approximately hemispherical, somewhat flattened at the apex, with a depression at the pole. The lower side is flattened against the substratum (Fig. 1, A, B). The diameter is .9 mm. and the height .5 mm. The chorion is white both before and after hatching though sufficiently translucent to reveal the sclerotised areas of the larva shortly before it emerges. The surface is traversed by two sets of ridges, each arranged spirally round the egg, and crossing the other approximately at right angles. At each point of junction of the sets a process is developed which projects outwards from the wall. This process tapers upwards from the base but expands again just before the apex, which is produced into four blunt peg-like outgrowths. (Fig. 1, E).

Hatching takes place after three or four days, and the larva escapes through an irregular dorsal hole, approximately .5 mm. in diameter.

The egg is laid almost anywhere on or near the flower or young fruit, but the outer whorl of the perianth and its junction with the peduncle are the positions most frequently selected. In most cases only one egg is laid on a flower, but it is not uncommon to find any number up to five present.

The Larva.

The newly hatched larva is between 1.3 and 1.9 mm. long, and is yellowish to pale green in colour. The prothoracic plate is pointed laterally and narrowed posteriorly. The body is sparsely covered with long brown setae, arranged in longitudinal rows. Each segment bears nine setae, comprising a group of three dorsally, a pair below this, and a group of four above the level of the prolegs. Each seta bears minute projections arranged spirally, and directed away from the body.

The larva may begin to feed as soon as it reaches the surface of the flower, but more usually it first travels to the edge of a segment of the perianth, and bores its way to the interior. Once it has reached the chamber between the perianth and the stamens, the larva seems to feed more or less indiscriminately on the perianth, stamens, or carpels. When the egg has been deposited on a young fruit, the larvae bore into the pulp without feeding at the surface. In the laboratory it was found that larvae could be reared on the pulp of fruit in any condition of maturity, and in all cases fed readily, but in the field no larvae were taken in any but the smallest fruit, and eggs are not commonly laid even on young fruit.

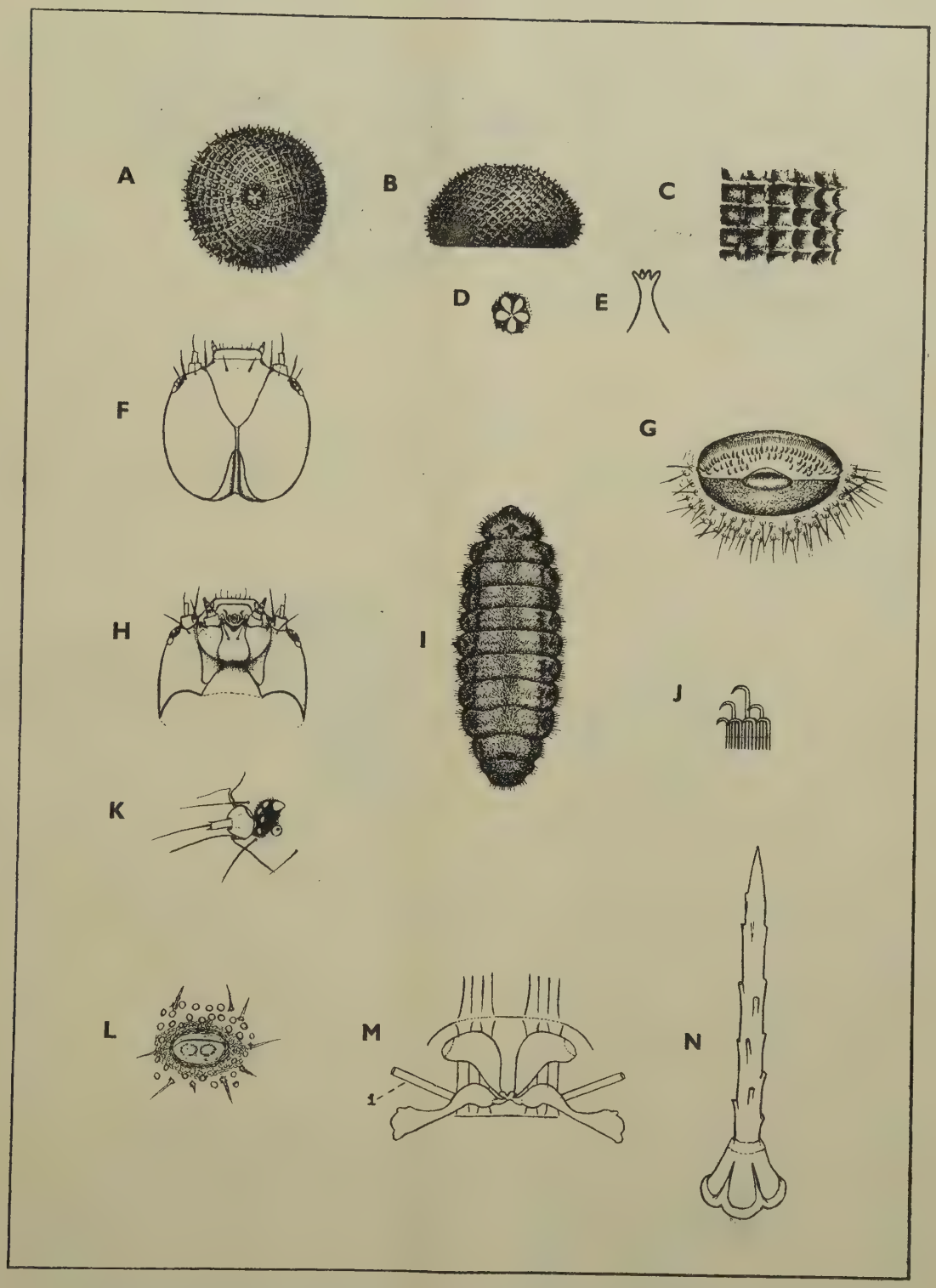

FIG. 1.—EGG.—A. seen from above. B. side view, after being laid. C. surface ornamentation. D. apical ornamentation. E. single projection, greatly enlarged. LARVA.—F. head, dorsal view. G. pro-leg, seen from below. H. head, ventral view. I. last instar, dorsal view. J. crochets of pro-leg. K. ocelli and antenna. L. external opening of dorsal gland. M. arrangement of sacs in late instar, showing (i) muscle to corner of external opening. N. hair of larva, greatly enlarged.

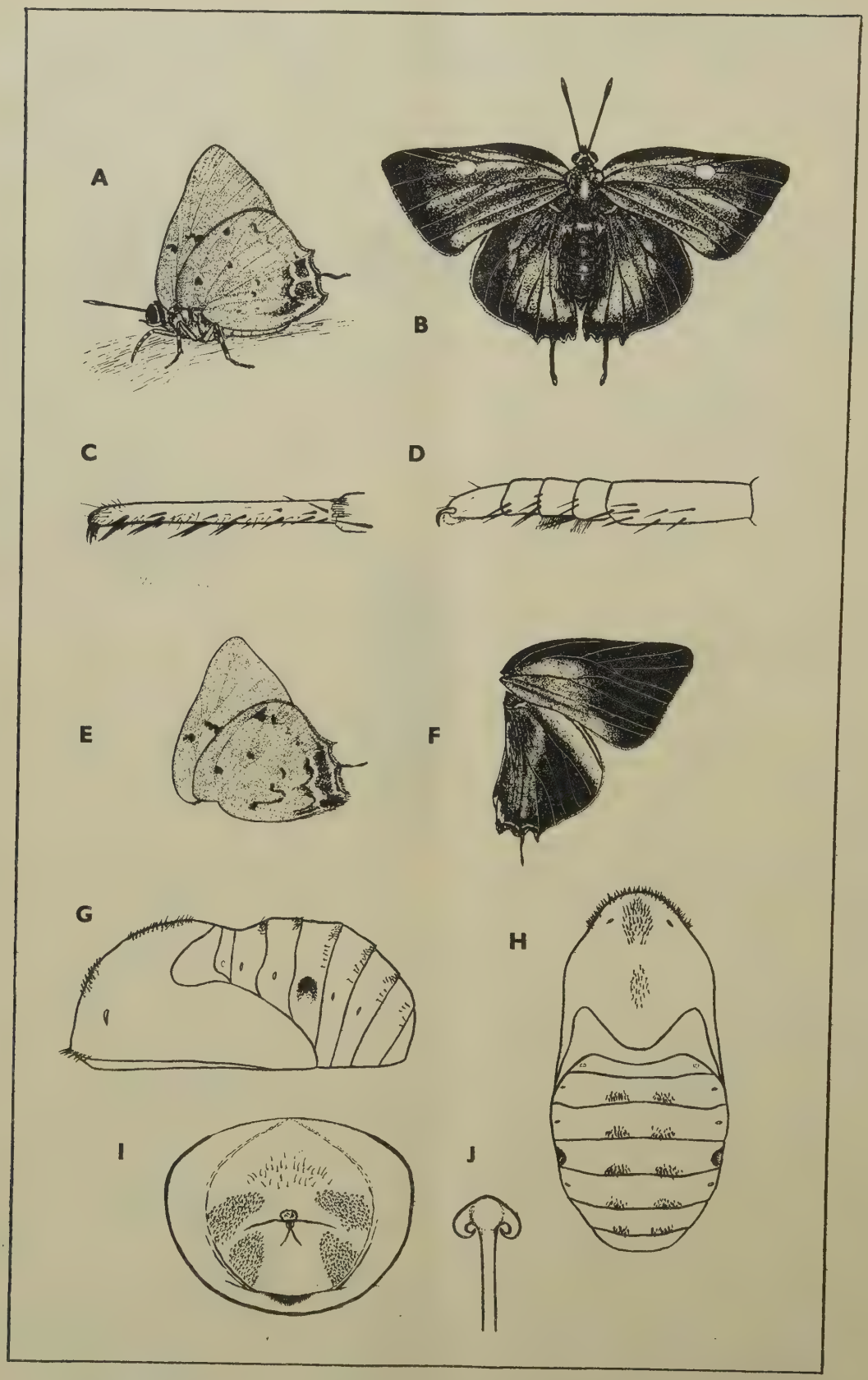

FIG. 2.—ADULT.—A. *T. ortygnus*, male, showing fore-leg as used when walking. B. *T. ortygnus*, male, × 3. C. tarsus of fore-leg of male. D. tarsus of fore-leg of female. E., F. ventral and dorsal wing patterns of female. PUPA.—G. side view. H. dorsal view. I. posterior of abdomen, showing tracts of hooklets. J. single hooklet, greatly enlarged.

As the larva grows the body colour deepens to greenish-brown, and the hairy pile on its body becomes more dense, but remains short. Each hair is lobed at the point of insertion.

In habits the larva is very sluggish, and during growth does not leave the particular flower or fruit on which it hatched. When fully fed, however, it migrates to a sheltered spot, and remains quiescent for two or three days. In this time its colour darkens, and the body becomes somewhat drawn in. Finally the larval exuviae are shed and the pupa is formed.

The fully grown larva is approximately 17 mm. long and 5.5 mm. in width. The head appears partly retracted, and the sides of the body are produced until they almost conceal the legs. The spiracles are white and broadly oval in shape. The opening of a paired gland is situated medially on the dorsum of the seventh abdominal segment (Fig. 1, L). The integument in this part can be drawn inwards to some extent by a muscle attached to each extremity of the opening, and passing outwards and downwards to the latero-ventral wall of the same segment. In addition a pair of delicate fibres traverses the integument, and is attached to one side of the dorsal opening of the gland. Below this opening lie two groups of sacs, joined medially, and projecting laterally above the heart and below the dorsal muscles. They vary in shape and size according to the degree of development of the larva (Fig. 1, M).

The mechanism of contraction is operated reflexly by a stimulus applied to the hairs around the opening of the gland. In the field, ants are sometimes to be found in attendance on the larva, when they drum rapidly on the sensitive area with their antennae. This process was observed on several occasions under the microscope, but no secretion of fluid or eversion of any part of the epidermal portion of the apparatus was observed, nor was it induced by an artificial mechanical stimulus. In some Lycaenid larvae a pair of eversible organs with an apical fringe of hair-like processes is found as well as the dorsal gland. These were not found to be present in the case of *T. ortygnus*.

Four moults are passed through before pupation occurs, and the total time spent in the larval stage is between 11 and 12 days.

THE PUPA.

The pupa is 12 mm. long and 5 mm. across at its widest part. The head and appendages are yellowish-brown, the thorax fuscous, and the abdomen a dark reddish-brown. The thorax is delicately reticulate, and bears a fringe of brown hair anteriorly and a medial patch farther back. The abdominal sterna are brown and smooth, passing laterally into a finely granular area, beyond which the epidermis is irregularly rugose. The dorsal surface is dark brown, with short scattered hairs. On each abdominal segment a tuft of hair lies on each side of the middle line dorsally, each tuft consisting of about 20 hairs directed backwards. A line of hairs is present on the posterior border just below the level of the spirales. Each spirale is pale yellow and is surrounded by an elevated, polished brown area; in the third abdominal segment the whole structure is situated at the base of a pronounced depression. The pupa is fastened down by a strand of silk passing over it in the region of the second abdominal segment, and, posteriorly, by four tracts of minute hooks, each shaped somewhat like an anchor (Fig. 1, J), which become entangled in a mat of brown silk laid down by the larva prior to its final ecdysis. The insect remains in the pupal stage for from 12 to 14 days.

THE ADULT.

The adult is about 12 mm. long and has a wing expanse of about 36 mm. As is frequently the case with Lycaenid butterflies, the sexes differ in coloration. In the males the wings are of an iridescent blue, with well-defined dark marginal areas. Between the third and fourth radial veins a brown spot is situated composed of dull brown elongated scales. These appear to correspond to the "androconia" or scent-scales described from other species of Lycaenidae. In the female the wings are a smoky blue, passing gradually into black towards the margin. In the hind-wing a sinuous white line, edged anteriorly with black, occurs immediately in front of two black spots at the posterior margin. The antennae are black, ringed with white, while the apical club is light brown. The under surface of the body is white, and the legs are alternately ringed with black and white. In the male the claws of the foretarsi are reduced and the tarsus terminates in a group of spines but in the female a pair of claws is present. Both sexes use the front pair of legs when walking: in the case of the male the tarsi are held stiffly downwards—the tarsal joints being non-flexible—and only the tip touches the surface which the insect traverses (Fig. 2, A).

Control.

In the majority of cases flowers which have been attacked fail to develop into fruit, so that if any measures are adopted, they must be preventative. The present value of the fruit would scarcely seem to justify definite measures being taken for the protection of the flower, but where it is considered worth while to attempt control the following methods may be tried.

(1) Where regular inspection of developing flowers can be carried out it is quite practicable to remove all the eggs. Usually not more than a single egg is present on a flower, and can be seen immediately as a pure white spot, and be readily dislodged. As the egg takes about three days to hatch inspection every two days should suffice.

(2) Flowers over half an inch in length may be sprayed with a weak suspension of lead arsenate, so that the newly hatched larvae may be poisoned in attempting to burrow inwards.

Reference.

1. Godman, F. D. and Salvind, O.—Biologia Centrali —Americana Insecta Lepidoptera. *Rhopalocera*, Vol. II.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Crystallizers and their Control. *Raymond Elliott.* **Reports of the Association of Hawaiian Sugar Technologists, 1936, pp. 261-262.**

This article, admittedly of an elementary nature is worth recording by reason of the clear way in which the author has summarized the essential data. Under normal conditions in low-grade massecuite work, he says, the vacuum pan will accomplish about 65 per cent. of the total purity reduction, leaving 35 per cent. to be done in the crystallizers. On a more exact basis, the percentages of sucrose crystallized on total sucrose, as indicated by the s-j-m. formula, are approximately 75 per cent. in the pan and 25 per cent. in the crystallizers.

Due to the time they require to reduce the mother-liquor purity of a massecuite to an economic minimum, the efficiency of crystallizers of the various types is quite low. Certain mechanical features, such as the shape and speed of the stirring mechanism and the addition of water coils, tend to increase the efficiency. In crystallizers with water coils, massecuites boiled to the maximum density may be cooled to a high minimum temperature and then maintained at this temperature for the remainder of the crystallizing period with much less danger of breaking or injuring the equipment. Coils will also permit the partial reheating of the massecuite a few hours prior to discharge, which not only facilitates the flow of massecuites from the crystallizers,but also lightens the needed capacity of the massecuite re-heaters.

At the present time many sugar factories are equipping or have equipped their crystallizers with water coils, which, however, do not necessarily increase the total recovery (1). Their function is chiefly to speed up crystallization and thus increase the capacity of the individual units and decrease housing space. By rapidly lowering the temperature of a crystallizer, the supersaturation coefficient tends to increase and the crystallization is accelerated, resulting in a more rapid reduction of the mother-liquor purity. The purity to which the mother-liquor in a given massecuite may be reduced (apart from its glucose-ash ratio) is dependent on density (viscosity), circulation and temperature

The viscosity at which the mother-liquor can be separated in a given case is dependent on the capacity of the centrifugal station, provided the purging quality of the grain is satisfactory. To offset viscosity, the massecuite is either heated or diluted, the former being the superior procedure because of the lower purities that result from working at a high final saturation temperature of approximately 50-55°C. or 120-130°F. Heating does not increase the mother liquor purity if the warming equipment is of sufficient capacity to operate at a small water-to-massecuite temperature differential, and if the massecuite saturation temperature is not exceeded.

In order to estimate the crystallizer performance, it is essential that the purity drop in the pans and crystallizers be determined separately. A systematic control on each crystallizer should be maintained, and the purity of the mother-liquor determined at the time of striking as well as just before the massecuite is given its final heating. The final purity obtained at the molasses scales should approximate to the purity of the mother-liquor at the end of the crystallizing cycle. If there is a large increase, say, over 0.5° it should be investigated to determine at which stage of treatment it has taken place. A third purity determination of mother-liquor separated from the massecuite as it is entering the centrifugal will show how much of the purity increase is due to imperfections in the heating (or dilution) and how much from crystals passing through or around the centrifugal screens in purging.—(*The International Sugar Journal*, Vol. XXXIX, No. 462. pp. 240-241, 1937.)

(1) Many modifications in crystallizers have been brought in various sugar-producing countries. *See* R. G. W. Farnell, *I.S.J.*, 1934, p. 264.

* * *

Oldest Specimen of Sugar.

According to an article in an American periodical by Dr. Brachwitz (1) there exists in the town of Nara in the state of Yamato in China a museum called the "Schose-in" founded in the year 742 A.D., in which are to be seen a number of valuable and remarkable antiquities. Among these is a collection of substances used in medicine, which have been preserved in chests, and one bearing the inscription "Sho-to" has been found to contain sugar. It is said to have been deposited there by a Chinese priest-physician Kan-jin or Kan-hin between the years 743 and 763. This, Dr. E. O. von Lippman remarks, (2) must surely be the oldest existing specimen of sugar in the world. — (*The International Sugar Journal*, Vol. XXIX, No. 462, p. 227, 1937.)

(1) *Isis*, 1936, 25 p. 63.

(2) *Deut. Zuckerind*, 1936, 61, p. 621.

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CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Light and Nitrogen Fixation in the Soil.

The current view is that the vicissitudes of the nitrogen cycle in the soil are mainly, if not entirely, to be interpreted in the light of the varying proportions and activities of the living soil population, both plant and animal. Under English conditions this may well be true; none the less these views would seem to deserve critical consideration in view of the evidence produced by Dr. N. R. Dhar of the significance of the action of light on the soil, under Indian conditions. With sterile conditions he has shown, in comparison between soils in light and dark, that the sunlight alone profoundly modifies photochemical oxidation of ammonia to nitrites and nitrates, the amount of production of nitric nitrogen in the air and therefore in the rain water, and the production of ammoniacal nitrogen in sterile soils containing such carbohydrates as cane sugar. Dr. Dhar in his enthusiasm may be swinging to the other extreme, but his experimental evidence is very striking, and the work deserves very full consideration both by biologists and soil chemists. He has given a very full summary of his work in a publication under the aegis of the Society of Biological Chemists, India, issued in 1935 under the title "Influence of Light on some Biochemical Processes" (Bangalore: Indian Institute of Science. One rupee).—(*Nature*, Vol. CXXXVII, No. 3463, p. 462, 1936.)

* * *

Animal Skeletons and Soil Phosphate.

It has recently been suggested by G. Lefort (*Bull. Assoc. Franc. Étude Sol.*, 1936) that the superior qualities of the Boulogne horse may be due to the high phosphate content of the soil on which their fodder is grown. Abundant phosphate in the ration may improve the bone structure and skeleton formation, as well as the horse's temperament.

* * *

Lenses from Plastics.

As a result of protracted research, an entirely new method has been invented for the production of optical systems (lenses and the like) from plastic materials. The invention is all-British in the full sense of the word; invented by an Englishman and based on the use of materials developed in British laboratories. It is likely to exercise a revolutionary influence on the whole optical industry. Indeed it is difficult to exaggerate its possible effects.

The invention, which consists of a moulding process, delivers from specially designed machines lenses already polished and ready for mounting into cameras, binoculars, opera glasses, telescopes, spectacles, range-finders, stereoscopes, scientific instruments and television apparatus. The lenses are made by special treatment for their particular purposes from various plastic and transparent materials. They are for all practical purposes unbreakable as well as being half the weight of glass and having certain optical properties which are stated to be superior to glass. One of the plastics used in the process is known as "Perspex" a material recently developed by Imperial Chemical Industries, Ltd. The invention consequently obviates all the long and expensive grinding and polishing processes in the hands of highly skilled labour which are at present necessary for the manufacture of optical systems.—(*Chemistry and Industry*, Vol. 56, No. 7, pp. 162-163, 1937.)

* * *

Selenium Toxicity.

Recent work by Dr. Annie Hurd-Karrer, of the United States Department of Agriculture, has shown that the absorption of selenium by the plant is retarded by adding sulphur compounds to a toxic seleniferous culture solution. Similarly, phosphorus compounds prevent the absorption by the plant of toxic arsenic. For example, the presence of 120 p.p.m. of phosphorus in a nutrient solution growing wheat plants prevents poisoning by 30 p.p.m. of sodium arsenate. Another pair of similar elements, namely potassium and rubidium, also show this antagonism. The principle involved here is an inhibition of toxicity by the presence of an excess of a chemically similar non-toxic element as a simple mass action, the plant not being able to differentiate between the two elements of the pair because of their chemical similarity. Also, Hurd-Karrer and Poos have shown that wheat plants, although growing without serious injury in a culture solution containing 3 p.p.m. or less of sodium selenate, nevertheless contained in their tissues enough selenium to cause the death of Aphids and Red Spiders which fed upon the plants. In soils, 10 p.p.m. of selenium showed little retarding effect on the growth of wheat, rye, oats and barley, but Aphid infestation was almost completely inhibited. A. L. Martin, of Columbia University, has emphasized the much greater toxicity of selenium to animals than to plants. Buckwheat plants, only slightly dwarfed by a seleniferous soil, caused early death of rats which ate the tissue, even after dilution with an equal weight of grain. Martin found that moderate rainfall and cropping had little effect in reducing the selenium content of the soil to which selenium had been added. O. A. Beath and C. S. Gilbert, of the Wyoming Agricultural Experiment Station, referring to the leafy carbonaceous shales with high selenium content, have suggested that these toxic areas have resulted from the progressive enrichment of selenium in the soil by cycles of growth and decay during late Cretaceous time, of highly seleniferous native plants, especially species of *Astragalus*.—(*Industrial and Engineering Chemistry, News Edition*, Vol. 15, No. 1, p. 2, 1937.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.).

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
27th May	6	5¼	10	3
3rd June	6	7½	10	4½
10th June	6	7½	10	4½
17th June	6	8¼	10	5¼
24th June	6	8¼	10	4½
1st July	6	9	10	5½
8th July	6	7½	10	4½
(9th *July*, 1936)	4	5¼	8	2¼

A very steady tone has prevailed in the market with quotations showing an improvement of 2½*d.* to 3*d.* per cwt. After a long period of quiet on the American market a good demand for raw sugar has developed at gradually advancing prices. Heavy buying, particularly of near July and September, was the main feature. In the United Kingdom the paucity of first-hand available sugars for the market has influenced sentiment. The increase of about 7 per cent. in the consumption of sugar in the chief European countries has been noted with some satisfaction.

* * *

COCOA.—The cocoa market has been comparatively quiet during the past month. Other than a fair amount of sales in Mid Crop Accra, little, if any business in actuals has transpired. For the immediate future we cannot foresee more than a trading market with the possibility of some price improvement during the late summer or early fall. Accra is quoted at 34*s.* 9*d.* c.i.f. for old crop and 35*s.* 3*d.* for new crop and locally $9.25 a fanega is paid for Plantation.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

COPRA has continued dull with the value of West Indian f.m.s. unchanged at £16 15*s.* c.i.f.

* * *

MANGOES.—A cargo of 475 boxes from Jamaica arrived in fair condition and met a good request, prices ranging from 4*s.* to 6*s.* per dozen.

* * *

LIME PRODUCTS.—*Lime Oil.* The nominal value of Handpressed is unchanged at 40*s.* per lb., for good quality, but the demand is slow. Distilled is inactive and unchanged at 25*s.* per lb. *Lime Juice.* Concentrated continues in limited demand at £5 17*s.* 6*d.* Spot supplies of Raw have been moved off at rather lower rates and the value now is 2*s.* to 2*s.* 3*d.*—(*West India Committee Circular*, 17th June, 1937.)

RUBBER.—Quotations for Plantation Sheet have ranged as follows:

	Pence per lb.
26th May	10 1/8
2nd June	9 13/16
9th June	9 7/16
16th June	9 1/2
23rd June	9 7/16
30th June	9 1/2
7th July	9 3/8
(8th *July*, 1936)	7 3/4

Prices have fluctuated within fairly narrow margins but on balance are a shade lower. Although news of the withdrawal of the N.D.C. was received with much satisfaction the general outlook remains uncertain in view of American labour troubles, political uncertainties in France and tension created by the Spanish situation. The decline in United Kingdom stocks, however, has continued while American consumption for the first five months of the year works out at 255,493 tons, representing an increase of 10.9 per cent. over the corresponding figure last season.

* * *

BANANAS.—According to the *West India Committee Circular* for 17th June, Jamaicas are unchanged at £18. 15*s.* per ton delivered London and £18 10*s.* nearest Station Provinces, and Brazilians at £16 delivered London and £17 delivered Provinces.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
28th May	7.36	11.56
4th June	7.31	11.27
11th June	7.06	10.84
18th June	6.92	10.00
25th June	6.95	10.05
2nd July	6.87	—
9th July	6.98	—
(10th *July*, 1936)	7.58	10.14

Prices for raw cotton have largely been influenced by reports on the progress of the American crop which so far are favourable. The labour troubles in U.S.A. and other political uncertainties have acted as bearish factors. Quotations for West Indian Sea Island have fallen considerably and as a result buyers have held off.